Dissertation on

A STUDY ON THE BRANCHING PATTERN AND VARIATIONS OF THE FEMORAL ARTERY AND ITS BRANCHES

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BRANCH-XXIII, ANATOMY

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TAMILNADU

APRIL 2015

CERTIFICATE

This is to certify that this dissertation entitled

"A STUDY ON THE BRANCHING PATTERN AND VARIATIONS OF THE FEMORAL ARTERY AND ITS BRANCHES"

is a bonafide record of the research work done by **Dr.S.ELIZABETH PRIYADARISINI,** Post graduate in the Institute of Anatomy, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-03, in partial fulfillment of the regulations laid down by The Tamil Nadu Dr. M.G.R. Medical University for the award of M.D. Degree Branch XXIII-Anatomy, under my guidance and supervision during the academic year 2012-2015.

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CERTIFICATE OF APPROVAL

To
Dr.S.Elizabeth Priyadarisini,
I year, M.D.Anatomy PG,
Madras Medical College, Chennai-3.

Dear S.Elizabeth Priyadarisini

The Institutional Ethics committee of Madras Medical College, reviewed and discussed your application for approval of the proposal entitled "A study on the branching pattern and variations of the Femoral Artery and its Branches" No.07062013.

The following members of Ethics Committee were present in the meeting held on 11.06.2013 conducted at Madras Medical College, Chennai -3.

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6. Prof. S. Deivanayagam MS -- Member
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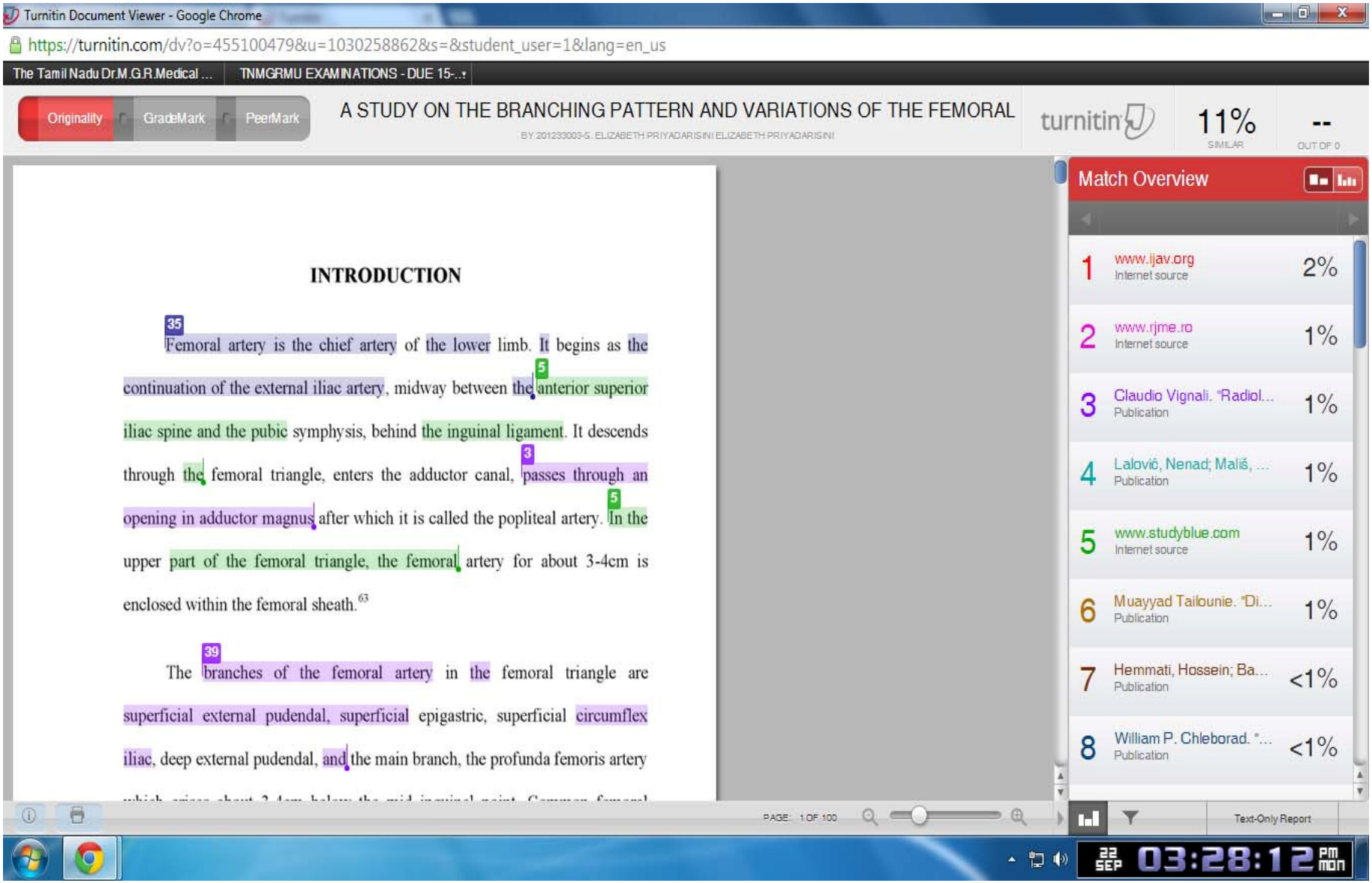
7. Thiru. S. Govindsamy. BABL -- Lawyer
8. Tmt. Arnold Saulina MA MSW -- Social Scientist

We approve the proposal to be conducted in its presented form.

Sd/ Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information / informed consent and asks to be provided a copy of the final report.

R.Nadhini 24/6/13
Member Secretary, Ethics Committee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INTRODUCTION
Femoral artery is the chief artery of the lower limb. It begins as the continuation of the external iliac artery, midway between the anterior superior iliac spine and the pubic symphysis, behind the inguinal ligament. It descends through the femoral triangle, enters the adductor canal, passes through an opening in adductor magnus after which it is called the popliteal artery. In the upper part of the femoral triangle, the femoral artery for about 3-4cm is enclosed within the femoral sheath.[63]
The branches of the femoral artery in the femoral triangle are superficial external pudendal, superficial epigastric, superficial circumflex iliac, deep external pudendal, and the main branch, the profunda femoris artery
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LEGEND

AH	-	Adductor Hiatus
AL	-	Adductor Longus
AM	-	Adductor Magnus
ASIS	-	Anterior Superior Iliac Spine
CT	-	Common Trunk
DGA	-	Descending Genicular Artery
EIA	-	External Iliac Artery
FA	-	Femoral Artery
FN	-	Femoral Nerve
FV	-	Femoral Vein
GSV	-	Great Saphenous Vein
IL	-	Inguinal Ligament
LCFA	-	Lateral Circumflex Femoral Artery
MCFA	-	Medial Circumflex Femoral Artery
MIP	-	Mid Inguinal Point
PFA	-	Profunda Femoris Artery
PS	-	Pubic Symphysis
SAR	-	Sartorius
SCIA	-	Superficial Circumflex Iliac Artery
SEA	-	Superficial Epigastric Artery
SEPA	-	Superficial External Pudendal Artery
SFJ	-	Sapheno Femoral Junction

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ABSTRACT

A STUDY ON THE BRANCHING PATTERN AND VARIATIONS OF THE FEMORAL ARTERY AND ITS BRANCHES

The superficial position of the femoral artery makes it readily accessible for catheterisation. The femoral artery is used in interventional cardiology procedures and as an access for permanent haemodialysis. The femoral artery and its main branch, the profunda femoris artery are used in arteriography and in doppler imaging. Skin flaps based on the superficial branches of the femoral artery are used in reconstructive procedures of the breast, upper and lower extremities.

It is difficult to achieve haemostasis in anomalous conditions, when the femoral artery is punctured for cannulation. Hence a detailed knowledge of the branching pattern of the femoral artery is needed to minimise complications. The anatomy of the femoral artery was studied in 50 adult lower limb specimens at the Institute of Anatomy, Madras Medical College. 25 adult femoral angiograms and 10 CT angiograms of the femoral artery from the Barnard Institute of Radiology, Rajiv Gandhi Government General Hospital were also studied.

The origin of the femoral artery coincided with the mid inguinal point in 88% and was lateral to it in 12%. The superficial epigastric artery arose as a

separate trunk from femoral artery in 88% and as a common stem with superficial external pudendal artery in 12%.There was duplication of superficial external pudendal artery in 8%.The profunda femoris artery arose from the posterolateral aspect of the femoral artery in 64%, from its posterior side in 24%, and from its lateral side in 12%. The mean length of the profunda femoris origin from the mid inguinal point was 4.31cm. The lateral circumflex femoral artery originated from the profunda femoris in 72% and from the femoral artery in 28%. The medial circumflex femoral artery originated from the profunda femoris in 64% and from the femoral artery in 36%. In the radiological study done, normal branching pattern was observed in 84% and variant branching pattern was seen in 12%.

The present study will be useful to the surgeons while operating around the femoral region. The knowledge of the femoral artery will also help the radiologists during interpretation of images, and the clinicians before proceeding with interventional procedures.

KEY WORDS:

Femoral artery, Mid inguinal point, Superficial epigastric artery, Superficial external pudendal artery, Profunda femoris artery, Lateral circumflex femoral artery, Medial circumflex femoral artery.

INTRODUCTION

Femoral artery is the chief artery of the lower limb. It begins as the continuation of the external iliac artery, midway between the anterior superior iliac spine and the pubic symphysis, behind the inguinal ligament. It descends through the femoral triangle, enters the adductor canal, passes through an opening in adductor magnus after which it is called the popliteal artery. In the upper part of the femoral triangle, the femoral artery for about 3-4cm is enclosed within the femoral sheath.[63]

The branches of the femoral artery in the femoral triangle are superficial external pudendal, superficial epigastric, superficial circumflex iliac, deep external pudendal, and the main branch, the profunda femoris artery which arises about 3-4cm below the mid inguinal point. Common femoral artery is the part of the femoral artery above the origin of profunda femoris artery.The part of the femoral artery below the profunda femoris artery origin is termed the superficial femoral artery. It gives off the descending genicular artery within the adductor canal.

In the femoral triangle, the anterior relations of the femoral artery are the femoral sheath, fascia lata, and the femoral branch of the genitofemoral nerve. The artery is crossed by the medial femoral cutaneous nerve at the apex of the femoral triangle from lateral to medial side. The femoral vein is medial

to the femoral artery in the upper part of the femoral triangle, but goes posterior to it at the apex of the femoral triangle.The femoral nerve lies lateral to the artery, outside the femoral sheath.[63]

Within the adductor canal, the saphenous nerve crosses the artery from lateral to medial side. Adductor longus and adductor magnus form the posterior relations, with the vastus medialis and its nerve lying anterolaterally.

The superficial circumflex iliac artery arises from the femoral artery, as a separate trunk or as common stem with superficial epigastric artery. It runs below the inguinal ligament to the lateral side towards the anterior superior iliac spine and terminates by anastomosing with the deep circumflex iliac, superior gluteal and lateral circumflex femoral arteries.

The superficial epigastric artery originates from the femoral artery, approximately 1 cm below the inguinal ligament. It crosses the ligament and runs upwards towards the umbilicus. It supplies the skin, superficial fascia, superficial inguinal lymph nodes and ends by anastomosing with branches of the inferior epigastric artery.

The superficial external pudendal artery starts from the femoral artery, close to the other superficial branches. Piercing the cribriform fascia, it passes deep to the long saphenous vein, to supply the skin of external genitalia and anastomoses with branches of the internal pudendal artery.[63]

The deep external pudendal artery arises from the femoral artery, passes medially, and after supplying skin of the external genitalia, anastomoses with branches of the internal pudendal artery.

The profunda femoris (deep femoral artery) is the main branch which originates from the femoral artery,about 3.5 cm distal to the inguinal ligament. Initially it lies lateral to the femoral artery, then goes posterior to the femoral artery and the femoral vein. It finally reaches the medial side of the femur, and piercing the adductor magnus muscle, anastomoses with the branches of the popliteal artery. In the upper thigh, the profunda femoris artery gives origin to lateral and medial circumflex femoral arteries and to the perforator and muscular branches more distally.[63]

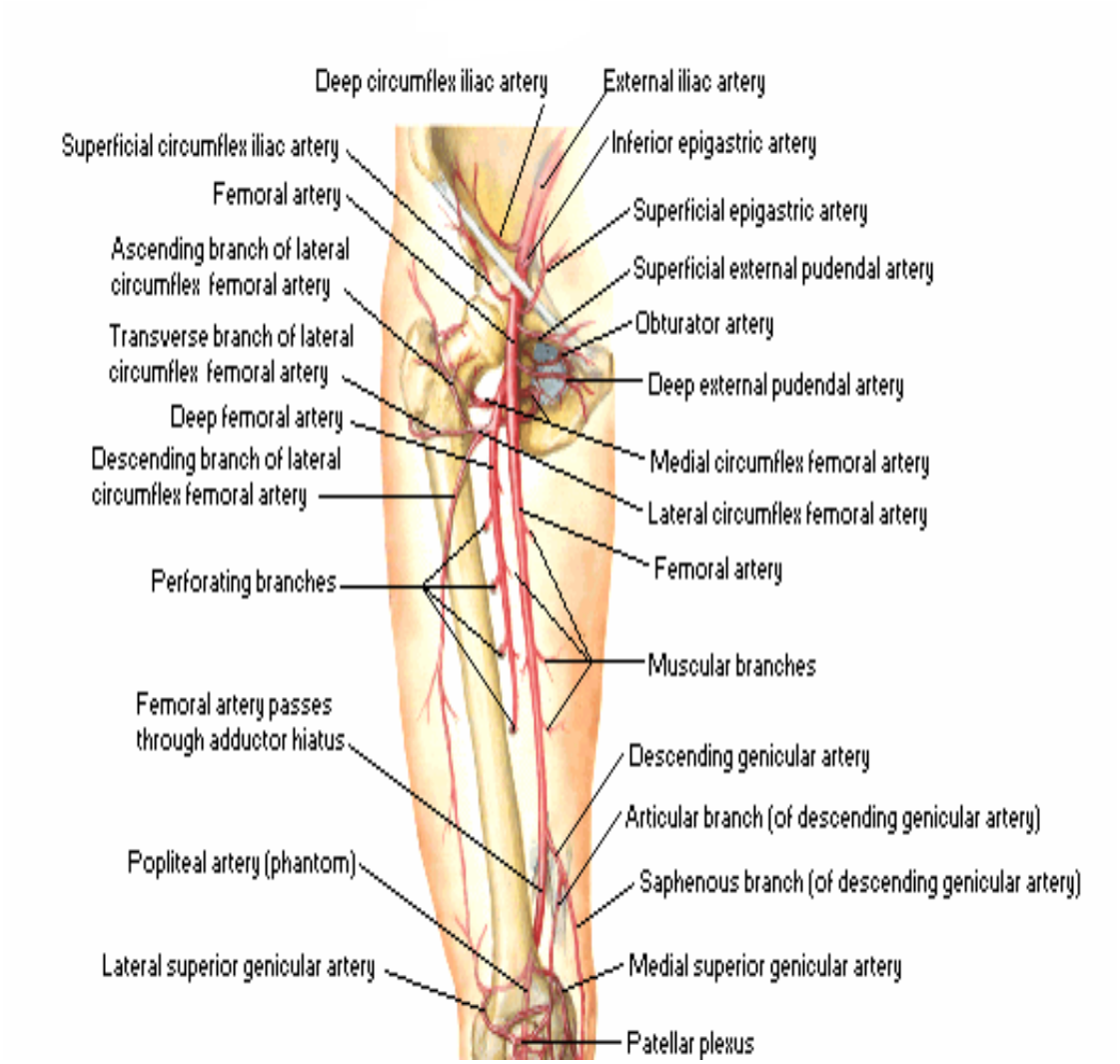
The lateral circumflex femoral artery arises from the profunda femoris artery near its origin and running laterally between the branches of the femoral nerve terminates by dividing into ascending ,transverse and descending branches.

The medial circumflex femoral artery also arises from the profunda femoris near its origin, goes posteriorly out of the femoral triangle, and then proceeds to the upper border of the adductor magnus, where it ends by dividing into transverse and ascending branches.

The perforator arteries are three in number and the terminal continuation of the profunda femoris artery is called the fourth perforator. The perforator arteries pierce the adductor magnus and form a chain of anastomoses along the adductor muscles.

The descending genicular artery arises from the femoral artery just above the adductor opening and gives rise to a saphenous branch and an articular branch to the knee joint. The saphenous branch pierces the roof of the adductor canal and proceeds to the medial side of the thigh along with the saphenous nerve.

FEMORAL ARTERY AND ITS BRANCHES



Aim of the study

AIM OF THE STUDY

The femoral artery is relatively superficial in position and this makes it readily accessible for catheterisation. Hence femoral artery can be used to investigate any arterial system in the body.

The femoral artery is useful in embalming procedures for the preservation of cadavers for research purposes.

The femoral artery at the groin is the most convenient site for collection of arterial blood samples. It is used in arteriography and doppler imaging. Advanced imaging techniques have come in to use, but arteriography still remains the main line of investigation in peripheral occlusive arterial diseases.

Modern techniques for diagnosis and treatment of cardiovascular disorders frequently require percutaneous penetration in to a peripheral artery. Femoral artery is used in interventional cardiology procedures such as invasive coronary angiogram and coronary balloon stenting.

The femoral artery is used by nephrologists as an access for permanent haemodialysis. It is also used by oncologists for delivering intra arterial chemotherapy.

The femoral artery serves as an important landmark for femoral nerve block given by anaesthetists.

Superficial external pudendal artery flaps can be used as pedicled flaps for reconstructive surgeries of upper and lower extremities. Superficial epigastric artery flaps are useful in breast reconstruction procedures. Superficial circumflex iliac artery perforator flaps can be used in penile reconstruction with the advantage of minimal donor site morbidity and a concealed donor scar.

Knowledge of circumflex femoral arteries is essential for orthopaedicians and surgeons while doing surgeries around the hip joint.

Profunda femoris artery is used for arteriography, ultrasound, doppler imaging, digital subtraction angiography and magnetic resonance imaging. It is frequently used in vascular reconstructive procedures in the proximal leg.

In anomalous conditions, if the artery is punctured during cannulation, it may be difficult to achieve haemostasis. Hence a detailed knowledge of the femoral artery and its branches is required to minimise complications.

As the femoral artery and its branches have such wide clinical applications, it is mandatory to know the normal branching pattern of the

femoral artery, and variations present if any, before proceeding with any diagnostic or interventional procedure.

PARAMETERS:

1. Origin of femoral artery in relation to the mid inguinal point.
2. Relation of femoral artery to femoral vein in the femoral triangle.
3. Site of origin of the superficial circumflex iliac artery.
4. Site of origin of the superficial epigastric artery.
5. Site of origin of the superficial external pudendal artery.
6. Relation of superficial external pudendal artery to the arch of great saphenous vein at the saphenofemoral junction.
7. Origin of the deep external pudendal artery.
8. Site of origin of the profunda femoris artery.
9. Distance of origin of the profunda femoris artery from the mid inguinal point.
10. Site of origin of lateral circumflex femoral artery.
11. Site of origin of medial circumflex femoral artery.
12. Origin of descending genicular artery.

Review of literature

REVIEW OF LITERATURE

ORIGIN OF FEMORAL ARTERY IN RELATION TO THE MID INGUINAL POINT.

J D Boyd et al [5] (1956) in Textbook of Human Anatomy, stated that the external iliac artery becomes the femoral artery behind the inguinal ligament midway between the PS and ASIS.

Sir John Bruce et al [61] (1964) in Manual of Surgical Anatomy, quoted that the FA enters the thigh behind the MIP.

W.Henry Hollinshed [75] (1966) in Textbook of Anatomy, stated that the chief vessels of the thigh are FA and FV, which are continuous at the inguinal ligament with no change in diameter, but with change in name with the external iliac vessels and similarly continuous below with the popliteal vessels.

Barry J Anson et al [2] (1971) said that the FA enters the thigh midway between the PS and ASIS.

G.J.Romanes [21] (1972) in Cunningham's Textbook of Anatomy, stated that the femoral artery begins behind the IL, and becomes continous with the popliteal artery at the opening in the adductor magnus.

Jeremy A Hunt et al [28] (1996) in Journal of Surgery**,** assessed patients undergoing arteriography, and observed that the MIP is an appropriate guide to the FA as it can be expected to lie within 1.5cm on either side of the MIP.

Dr.P D Scott et al [14] (2005) in his study of 40 cadaveric limbs, stated that the surface markings of the deep inguinal ring and the FA was found to lie closer to the MIP than to the midpoint of the inguinal ligament**.**

Susan Standring [63] (2008) stated that the FA is a continuation of EIA, which begins behind the IL, midway between the PS and ASIS.

Keith.L.Moore [29] (2010) in Clinically Oriented Anatomy, reported that the FA is the continuation of EIA, distal to the IL, and also stated that it is the primary artery of the lower limb.

Chummy.S.Sinnatamby [8] (2011) in Last's Anatomy reported that the FA enters the thigh at a point midway between the anterior superior iliac spine and pubic symphysis.

Richard.S.Snell [55] (2012) in Clinical Anatomy by Regions, stated that the FA enters the thigh behind the IL, as a continuation of the EIA. Here it lies midway between the ASIS and the PS.

RELATION OF FEMORAL ARTERY TO THE FEMORAL VEIN IN THE FEMORAL TRIANGLE

Barry J Anson et al [2] (1971) quoted that the FV lies medial to FA at the inguinal ligament. Sometimes the FV may lie anterior or lateral to the FA. In the adductor canal it is at first posterior and then goes to the lateral side of the FA.

G.J.Romanes [21] (1972) in Cunningham's Textbook of Anatomy, stated that the femoral vein lies behind the artery in the lower part of the femoral triangle, but passes to its medial side above.

Baum PA et al [3] (1989) assessed variations in the relation between FA and FV by reviewing 100 CT scans of the pelvis and reported that in 73% there was a partial overlap of the FA on the FV, and in 27% the femoral vein maintained a medial relationship to the FA.

D.Hughes et al [26] (2000) reviewed 50 patients with ultrasound, and stated that there was no overlap of the FV on the FA in 72% of patients at the level of inguinal ligament.

Faith Kantarci M B et al [18] (2003) stated in a case report, duplication of superficial femoral artery in a 60 year old male patient. The FV was normal and lying posterior to the duplicated superficial femoral artery.

Fred H Warkertine et al [19] (2008) assessed the relation of the FV to FA by ultrasonography and reported that the FV completely overlapped the FA in 8%, partially overlapped the FA in 4% and in 88% the FV was medial to the FA in the femoral triangle.

Keith.L.Moore [29] (2010) in Clinically Oriented Anatomy**,** reported that the FA enters the femoral triangle deep to the midpoint of the IL, lateral to the FV.

Beaudoin FL et al [4] (2011) studied 180 adult patients,who underwent ultrasonography to identify the amount of FV exposed at and below the level of the IL.They observed that the percentage of FV exposed at the level of IL was 83%,which decreased to 65% at 2cm from the IL. It further decreased to 56% at 4 cm from the IL.There were patients with no vein exposed at every level away from the IL.The study concluded that there is significant overlap of the femoral vessels at sites where FV cannulation is often done.

Punita Sharma et al [51] (2011) during routine dissection, found that FV was posterolateral to the FA as it entered the adductor canal. In the adductor canal, there was duplication of FV.The superficial component of the FV wound around the anteromedial aspect of FA to lie superficial to the FA,while the deep component went up as the usual FV,posterior to the FA.In the femoral

triangle, the superficial component of the FV went around the FA,to unite with the deep component, posterior to the FA.

Tailounie M et al [65] (2012) studied the overlap of femoral vessels, at the level of IL,and 1 cm below the IL in a straight hip and in external rotation with abduction of the hip. Overlap between the FV and the FA at the level of IL was 57 to 79% and 43 to 98% at 1 cm below the IL.They concluded that there is a high degree of overlap between the FA and FV, and the degree of overlap did not decrease with external rotation with abduction of the hip.

Nayak.B.S et al [44] (2013) reported a case where the inferior epigastric artery and deep circumflex iliac artery took origin from the FA bilaterally.

SITE OF ORIGIN OF THE SUPERFICIAL CIRCUMFLEX ILIAC ARTERY

George A Piersol [23] (1930) stated that SCIA arises from anterior surface of FA below the SEA or as a common trunk with SEA.

Parson's Schaeffer [27] (1952) in Morris Human Anatomy**,** quoted that the SCIA arises in common with SEA or as a separate branch from FA.

Taylor and Daniel [68] (1975) reported from 20 operated cases, that in 25% of cases SCIA was absent, in 45% it arose as a separate trunk from FA, in 15% as a common stem with SEA and in 15% as a CT with SEPA.

Robert J Allen et al [56] (2002) investigated the anatomy of SEA in 100 cadavers and reported SCIA and SEA arise as a CT in 79%, 2 cm below the IL.

Mangala M Pai et al [37] (2006) reported in a 65 year old male cadaver, that a branch arose from the FA distal to the PFA from its anteromedial side which divided in to three branches SEA, SEPA and DEPA. The SCIA was absent.

Susan Standring [63] (2008) stated that the SCIA arose near or along with the SEA.

Dr.Manjappa T et al [12] (2012) in their study of 40 femoral triangles on 20 embalmed cadavers, reported that SCIA arises from FA as a separate branch in 52.5% of cases, from FA by a CT with SEA in 40%. It arose from FA by a common trunk with SEPA and SEA in 2.5%, from PFA in 5%.

PMergu et al [40] (2014) stated in a case report that the SCIA and SEA originated as a common trunk from the anterolateral aspect of the PFA.

SITE OF ORIGIN OF SUPERFICIAL EPIGASTRIC ARTERY

W.Henry Hollinshed [7] (1966) in Textbook of Anatomy, said that SEA tends to arise from the anterior surface of femoral artery.

Romanes G J [21] (1972) said that the SEA, one of the branches of the femoral artery arises near the SCIA.

Taylor and Daniel [68] (1975) observed that the SEA arose as a CT with SCIA in 15%, separate trunk from FA in 70%, as CT with SEPA in 15%.

Reardon et al [53] (2004) in their dissection of 44 lower limbs in 22 cadavers, reported that in 15 cases, the SEA originated within 1cm of the midpoint of the IL, in 17 cases within 2cm of the IL, and in 8 cases it originated as a common trunk with SCIA, SEPA and deep circumflex iliac artery. SCIA was absent in 4 cases.

Mahdi Fathi et al [34] (2006) in their 40 dissections on 20 preserved male cadavers, reported that the SEA originated directly from the FA as an individual trunk in 57.9%, as a CT with the SCIA in 18.4% of cases and as a CT with SEPA in 5.3% of cases. It arose as a common trunk with superficial femoral artery in 13.2%.The SEA was absent in 5.2%. In 10% of cases, double SEA's were seen arising from the FA with a common or double trunk.

Remya M et al [54] (2007) observed an unusual branching pattern of the FA in right lower limb of an adult male cadaver and said that the SEA and SEPA was seen arising as a CT from the medial side of femoral artery.

Chummy S Sinnathamby [8] (2011) in Last's Anatomy stated that the SEA crosses the IL, and it is distributed to the skin of the lower abdominal wall.

Dr.Manjappa T et al [12] (2012) observed that the SEA arose from femoral artery as a separate trunk in 47.5%, from FA by a common stem with SCIA in 35%, from FA by common trunk with SEPA in 10%, from FA by a CT with other arteries in 7.5%.

SITE OF ORIGIN OF SUPERFICIAL EXTERNAL PUDENDAL ARTERY

George A Piersol [23] (1930) stated that the SEPA arose from the medial surface of the FA and courses medially towards the external genitalia.

Castro.M. et al [6] (1998) in their dissection of 20 cadavers, found that the SEPA arose as a single vessel in 55%, duplicated in 30%, and by a common trunk with SEA in 15%.

Ercan Tanyeli et al [17] (2006) in a case report stated that the SEPA and the inferior epigastric artery arose from the PFA.

Osvaldir Lanzoni La Falce et al [32] (2006) in their 50 dissections of the inguinal regions in male cadavers , observed that the SEPA originated from the FA in 98% of cases, and from the PFA in 2%.The SEPA was found to be duplicated in 46%, the division produced a superior and an inferior SEPA. It was found as a CT with other superficial arteries in 24%, and as a single artery in 30%.

Susan Standring [63] (2008) stated that the SEPA arises medially from the FA, near the other superficial branches.

Manal.E.EL-Sawaf [36] (2010) reported a case of unusual origin of SEPA, where the SEPA and the inferior epigastric artery originated by a CT from the medial side of the EIA.

. **Dr. Manjappa T et al [12] (2012**) , stated that the SEPA arises as a separate branch from FA in 57.5%, from FA by a common trunk with DEPA in 25%, by CT with SEA in 10%, by common trunk with SEA and SCIA in 2.5%, from PFA in 5%.

RELATION OF SUPERFICIAL EXTERNAL PUDENDAL ARTERY TO THE ARCH OF GREAT SAPHENOUS VEIN AT THE SAPHENOFEMORAL JUNCTION

M.Donnelly.S.Tierney et al [11] (2005) in their 2089 groin dissections, recorded that the SEPA was not visualized in 73.1%, was anterior to the long saphenous vein in 16.8%, and above the SFJ in1.1%.

Ass Ndaiye et al [1] (2006) in their 54 inguinofemoral dissections, found that the SEPA crossed behind the arch of GSV in 56% of cases and anterior to it in 44% of cases.

Preethi [50] (2008) in her 50 dissections, recorded the relation of SEPA to the GSV, and stated that the SEPA was not visualized at the saphenofemoral junction in 74%, the SEPA passed posterior to the GSV in 16%, and anterior to it in 10%.

Hemmati H et al [25] (2012) studied 228 patients with varicose veins who underwent surgery during two years and stated that SEPA crossed anterior to the GSV in 39.5% , crossed posterior to GSV in 60.5%.

ORIGIN OF DEEP EXTERNAL PUDENDAL ARTERY

George A Piersol [23] (1930) stated that the DEPA arises from the medial side of the FA below the SEPA, or as a CT with SEPA.

Russel T Woodburne [57] (1957) in Essentials of Human Anatomy, said that the DEPA arises from the medial side of the FA.

Sir John Bruce et al [61] (1964) reported that the DEPA arises from the FA near its origin.

Barry J Anson et al [2] (1971) stated that the DEPA arises from the medial aspect of the FA.

Romanes G J [21] (1972) said that the DEPA runs medially, pierces the cribriform fascia, and ends in the scrotum or labium majus.

Nam Y S et al [42] (2005) stated that the SEPA is located above the saphenous opening, and the DEPA is located below the saphenous opening.

Nachiket Shankar et al [41] (2009) reported that the DEPA arose from the MCFA bilaterally.

Mamatha H et al [35] (2012) in their dissections of 40 limbs in a North Indian population, reported a low origin of the DEPA, about 5 cm from the MIP.

Richard S Snell (2012) [55] stated that DEPA runs medially and supplies the skin of scrotum or labium majus.

Suthar K et al [64] **(2013)** observed in their dissections of 50 femoral triangles, that the DEPA arises from the medial side of the FA in 96% of cases, and in 4% it arises from its antero medial side.

SITE OF ORIGIN OF THE PROFUNDA FEMORIS ARTERY

Parson's Schaeffer [27] **(1952)** stated that the PFA arises from the posterolateral side of the FA.

Siddharth P et al [45] **(1985)** stated that the PFA arose from the posterolateral aspect of the FA in 52%, from the posterior aspect in 37%, from the posteromedial or medial aspect in 11%.

Dixit D P et al [10] **(2001)** in their dissections of 48 femoral triangles in 24 human cadavers, stated that the PFA originated from the postero lateral aspect of the FA in 35.41%, from the posterior aspect in 31.25%, the remaining from the lateral aspect of the FA.

Ercan Tanyeli et al [17] **(2006)** reported a variation of the FA in a 72 year old male cadaver. The PFA arose from the anterior aspect of the FA.

Dr.Marina Baptist et al [13] (2007) in their dissection of 40 femoral triangles, observed that the PFA arose from the posterolateral side of the FA in all the cases.

R Chitra [52] (2008) observed a rare variation of the PFA in her dissections of 50 femoral triangles. The PFA and the MCFA originated from the medial side of the FA by a CT, to pass in front of the FV.

M B Samarawickrama et al [39] (2009) observed in their 26 dissections of femoral triangles, the PFA originated from posterior aspect of FA in 12 cases, from posterolateral side in 8 cases, from lateral aspect in 6 cases.

Nachiket Shankar et al [41] (2009) found out during dissection of a middle aged male cadaver, that the PFA arose from the posterolateral aspect of the FA on the right side, from the lateral side of the FA on the left side.

Keith L Moore [29] (2010) in Clinically Oriented Anatomy, stated that the PFA arises from the lateral or posterior side of the FA.

Prakash et al [49] (2010) in his dissections on 64 extremities of 32 embalmed cadavers, stated that the PFA arose from the postero lateral aspect of the FA in 50%, from the posterior aspect in 46.9%, from the medial side of the FA in 3.1%.

Chummy S Sinnathamby [8] (2011) stated that the PFA originated from the lateral side of the FA.

Daksha Dixit et al [9] (2011) in their dissections of 228 femoral triangles in 114 human cadavers in North Indian population, found that the PFA arose from the posterolateral aspect of the FA in 42.1%, posterior aspect in 28.5%, lateral side in 18.8%, and from the medial side of the FA in 10.6%.

Kulkarni R N et al [31] (2012) during routine dissection of a lower limb of a male cadaver aged 50 years, reported that the PFA on both sides was seen arising from the medial side of the FA.

Siriporn Thitilertdecha et al [62] (2012) investigated 224 femoral triangles in 112 human cadavers, observed that the PFA separated from the posterior aspect of FA in 44.64%, from the postero lateral aspect in 30.36%, from lateral aspect in 21.43%, from medial aspect of FA in 3.57%.

Sabnis A S [59] (2013) dissected 60 femoral triangles and studied the origin, course and branches of PFA.They found that the PFA arose from the lateral aspect of the FA in 86%, and from the posterolateral side of the FA in 14%.

Suthar K et al [64] (2013) in their dissections of 50 femoral triangles in North Indian population, stated that the PFA originated from the posterior

aspect of the femoral artery in 8%, from posterolateral aspect in 52%, and from the lateral aspect of the femoral artery in 40%.

Vijisha Phalgunan et al [70] (2013) stated in a case report, a high origin of PFA, where the PFA arose beneath the IL, from the medial side of the FA, and coursed down behind the FV.

Nasr AY et al [43] (2014) stated that the PFA arose from the posterolateral aspect of the FA in 42%, from posterior aspect in 24%, from lateral side in 20%, from the posteromedial side of the FA in 14 %.

Vishal K et al [71] (2014) in their study of 46 femoral triangles, reported that the PFA arose from the posterolateral aspect of the FA in 65.22%, from the lateral side in 10.86%, from the posteromedial aspect of the FA in 10.86%, from the posterior aspect in 13.04%.

DISTANCE OF ORIGIN OF THE PROFUNDA FEMORIS ARTERY FROM THE MID INGUINAL POINT

Russel T Woodburne [57] (1957) said that the PFA arises 5 cm below the IL.

W.Henry Hollinshed [75] (1966) stated that the PFA arises from the FA, approximately 4-5cm below the IL.

Siddharth P et al [45] (1985) in their 100 dissections of lower limbs, stated that the origin of PFA from the MIP was at a distance of 4.4cm. In 1%, the PFA arose at the level of IL.

Voboril R [73] (1990) reviewed 253 lower limbs arteriograms, and stated that the PFA originated at or above the IL in 1.2%.

Perera J et al [47] (1995) in their dissection of 124 femoral triangles, noted that there is a distal migration of PFA origin, when either or both circumflex femoral arteries arose from the FA.

Dixit D P et al [10] (2001) described the distance of origin of the PFA from the MIP to be 4.75cm.

Mangala M Pai et al [37] (2006) in their dissection of a 65 year old male cadaver observed that the PFA arose from the FA about 1.2 cm below the inguinal ligament.

Dr.Marina Baptist et al [13] (2007) stated that the average distance of origin of the PFA from the midpoint of the IL was between 30-40mm. Only in 10% of cases, the PFA origin was between 60-70mm.

Vuksanovic-Bozanc A et al [74] (2007) stated that the PFA originated at a distance of 3.75 cm from the MIP.

E.Ciftcioglu et al [15] (2009) in a case report stated that the PFA originated at a distance of 55mm from the IL.

M B Samarawickrama et al [39] (2009) observed that the PFA origin was at a distance of 50mm from the MIP.

Nachiket Shankar et al [41] (2009) observed high origin of PFA bilaterally, where PFA arose 4mm distal to the IL on the right side, and 8mm distal to the IL on the left side.

Prakash et al [49] (2010) stated that the mean distance of origin of PFA from the MIP was 4.2cm.

Chummy S Sinnatamby [8] (2011) stated that the PFA arises about 3-4 cm distal to the IL.

Vishal Kumar et al [72] (2011) reported a case of high origin of PFA, originating just lower to the IL.

Kulkarni R N et al [31] (2012) stated that the PFA arose 4 cm below the MIP.

Mamatha H et al [35] (2012) found that the PFA originated at a distance of 3.9cm from the MIP.They also reported one case of high origin of PFA, where the artery branched out from the FA at a distance less than 1cm from the MIP.

Richard S Snell [55] (2012) in Clinical Anatomy by regions, observed that the PFA arises about 4 cm below the IL.

Siriporn Thitilertdecha et al [6] (2012) observed that the mean distance of origin of the PFA from the MIP was 34.61mm.

Pooja Jain et al [48] (2013) during routine dissection of a middle aged male cadaver , observed that the PFA arose 2 cm distal to the MIP on the right side, and a high origin of PFA from FA at the level of MIP on the left side.

Sabnis A S [59] (2013) stated that the distance of PFA origin from the midpoint of IL was 3.2 cm.

Suthar K et al [64] (2013) in their dissections of 50 femoral triangles, found that the PFA arose at a distance of 46.2mm from the MIP.

P Mergu et al [40] (2014) said in a case report, that the PFA arose 1 cm below the IL.

Vishal K et al [71] (2014) reported that the average distance of origin of PFA from the MIP was 39.95mm.

SITE OF ORIGIN OF LATERAL CIRCUMFLEX FEMORAL ARTERY

W.Henry Hollinshed [75] (1966) reported that the LCFA typically arises from the upper end of the PFA, but in 15% it arises from the FA, above the profunda femoris artery.

Romanes G J [21] (1972) observed that the LCFA springs from the PFA near its origin.

Massoud T F et al [38] (1997) stated that the LCFA took origin from the PFA in 81% and from the FA in19%.

Dixit D P et al [10] (2001) stated that the LCFA was given off from the PFA in 83.34% and from the FA in 16.66%.

Fukuda H et al [20] (2005) in his angiographic study, described that the LCFA was given off from the PFA in 78.6%, from the FA in 21.4%

.

Ercan Tanyeli [17] (2006) said in a case report, that the LCFA arose from the lateral side of the FA, and the origin was distal to the PFA origin. In this case, the inferior epigastric artery arose from the PFA.

Tanyeli E et al [67] (2006) reported double LCFA in 2% of cases. In 2% the PFA, LCFA and MCFA had a CT origin.

Choi SW et al [7] (2007) reported that the origin of LCFA was from the PFA in 86.8%, and from the FA in 13.2%.

Tansatit T et al [66] (2008) stated that the LCFA arose from the PFA in 56.67%, from the FA in 43.33%

Uzel M et al [69] (2008) investigated 110 inguinal regions, and said that the LCFA originated from the PFA in 77.3%, from the FA in 22.7%. In 1.8% of cases, the ascending and descending branches of LCFA was found to arise directly from the PFA or FA, in 0.9% LCFA had a CT origin with PFA and in 0.9% the PFA, LCFA and the MCFA arose by a common trunk.

M B Samarawickrama et al [39] (2009) observed in their dissections of 26 femoral triangles, found that the LCFA originated from the PFA in 92.3%, whereas it arose from the FA as common stem with PFA in 7.7%.

Prakash et al [49] (2010) observed that the LCFA arose from the PFA in 81.25%, from the FA in 18.75%.

Chummy S Sinnatamby [8] (2011) stated that the LCFA arises from the PFA, or occasionally from the FA.

Daksha Dixit et al [9] (2011) in their dissections of 228 femoral triangles, observed that the LCFA originated from the PFA in 72.8%, and from the FA in 27.2%. Origin from the FA included CT with PFA in 17.5%. All three branches of the LCFA arose directly from the PFA in 0.8%. Rare origin of LCFA, from the EIA was seen in 0.8%.

Mamatha H et al [35] (2012) in their dissections of 40 limbs in a North Indian population, stated that in 2.5% of cases the descending branch of the LCFA originated from the FA, in 2.5% of cases the descending branch of LCFA branched out as a separate trunk from PFA. In 2.5% the ascending and transverse branches of the LCFA were found to emerge as a CT originating from the PFA.

Sinkeet SR et al [60] (2012)in their 84 dissections from 42 cadavers to explore the LCFA , reported variant origin of LCFA .The LCFA arose from PFA in 65.5%, from FA in 34.5%. Origin from FA included CT with MCFA in 14.3% and as a separate trunk in 2.4%. It arose as a CT with PFA in 10.7%, as a trifurcation with PFA and MCFA in 7.1%,

Pooja Jain et al [48] (2013) reported a double LCFA in their case report of a male cadaver during routine dissection.

Sabnis A S [59] (2013) stated that the LCFA originated from the PFA in 80% and from the FA in16.7%. In 3.3% the LCFA was found to be absent.

Suthar K et al [64] (2013) reported that the LCFA originated from the PFA in 80%, and from the FA in 20%.

Vijisha Phalgunan et al [70] (2013) in a dissection of lower limb in an adult male cadaver, observed that he LCFA branched out from the FA directly, distal to the origin of PFA and then branched in to ascending, transverse and descending branches.

Mergu P et al [40] (2014), stated in a case report, that LCFA arose from the PFA 6cm below its origin and showed a normal branching pattern.

Pavan P Havaldar et al [46] (2014) in dissection of 50 adult lower limbs, reported that the LCFA originated from the PFA in 90%, and from the FA in 10% of cases.

SITE OF ORIGIN OF MEDIAL CIRCUMFLEX FEMORAL ARTERY

W.Henry Hollinshed [75] (1966) observed that the MCFA typically arises from the medial or posteromedial side of the PFA, but has an independent origin from the FA, more frequently than does the LCFA.

Romanes G J [21] (1972), stated that the MCFA arises from the PFA, at the same level as LCFA.

Lippert H, Pabst R [33] (1985) stated that the MCFA arose from the PFA in 58%, and from the FA in 42%.

Siddharth P et al [45] (1985) in their dissections of 100 lower limbs , said that the MCFA arose from the PFA in 63%, from the FA in 37 %.

Emura S et al [16] (1989) stated that the MCFA originated from the PFA in 61.7%, and from the FA in 38.3%.

Clarke S M et al [58] (1993) in their dissection of 30 cadaveric specimens examined the origin ,course, and distribution of MCFA, and observed that the origin of MCFA was from the PFA in 53% and was from the FA in 47%.

Massoud T F et al [38] (1997) assessed the variational patterns of the PFA and reported that MCFA originated directly from PFA in 81%, and from the FA in 19%.

Gautier E et al [22] (2000) reported that the MCFA arose from the PFA in 83.3%, and from the FA in 16.7%.

Kopuz et al [30] (2000) stated in a case report, that there was a CT origin of MCFA and inferior epigastric artery from the FA.

Dixit D P et al [10] (2001) in their dissections of 48 femoral triangles in 24 human cadavers, stated that the MCFA was given off from the PFA in 62.5% and from the FA(including common stem) in 37.5%. In 1 case,the MCFA was seen arising from the FA superior to the PFA, and it passed anterior to the FV.

Tanyeli E et al [67] (2006) found that the origin of MCFA was from the PFA in 79% , and from the FA in 21%.

Susan standring [63] (2008) stated that the MCFA arises from the posteromedial side of the PFA, but often arises from the FA.

E.Ciftcioglu et al [15] (2009) reported a variation of the MCFA in a male cadaver aged 55 years, in which the MCFA branched off from the postero lateral aspect of the femoral artery, 32 mm distal to the IL.

M B Samarawickrama et al [39] (2009) observed that the MCFA arose from the PFA in 62%, from the FA in 38%.

Keith L Moore [29] (2010), stated that the MCFA and LCFA arises from the PFA, may arise from the FA.

Prakash et al [49] (2010) found that the MCFA originated from the PFA in 67.2%, from the FA in 32.8%.

Chummy S Sinnatamby [8] (2011) stated that the MCFA, arises from medial side of the PFA, and occasionally from the FA, often above LCFA.

Daksha Dixit et al [9] (2011) stated that the MCFA arose from the PFA in 56.1%, from FA in 43.9%.

Mamatha H et al [35] (2012) found that the MCFA arises from the FA in 2.5% of the cases and from the PFA in the rest of the cases.

Suthar K et al [64] (2013) stated that the MCFA originated from the PFA in 64%, from the FA in 36%.

P Mergu et al [40] (2014) stated in a case report that the MCFA originated from the posterior aspect of the PFA, very close to PFA origin below the IL. In this case the deep circumflex iliac artery also arose from the PFA.

ORIGIN OF DESCENDING GENICULAR ARTERY

George A Piersol [23] (1930) stated that the DGA originates from the FA, just before it passes through the adductor magnus.

Russel T Woodburne [57] (1957) quoted that the DGA is given off from the FA, just before it passes through the adductor hiatus.

W.Henry Hollinshed [75] (1966) said that the FA gives off its last branch, the DGA, which is usually the only one arising in the adductor canal.

Romanes G J [21] (1972) stated that the DGA arises low in the adductor canal, from the FA.

Gocmen-Mas N et al [24] (2012) in which they dissected the pedicles of the saphenous flap in 32 legs of 16 adult cadavers, found that the DGA originated from the FA in all the cases.

Richard S Snell [55] (2012),in Clinical Antomy by Regions, reported that the DGA is a small branch that arises from the FA, near its termination.

Suthar K et al [64] (2013) observed that the DGA arises from the superomedial side of the FA.

Mergu P et al [40] (2014) stated that an additional DGA was given off from the PFA 6cm below its origin, which descended down to end in genicular anastomosis.

Embryology

EMBRYOLOGY

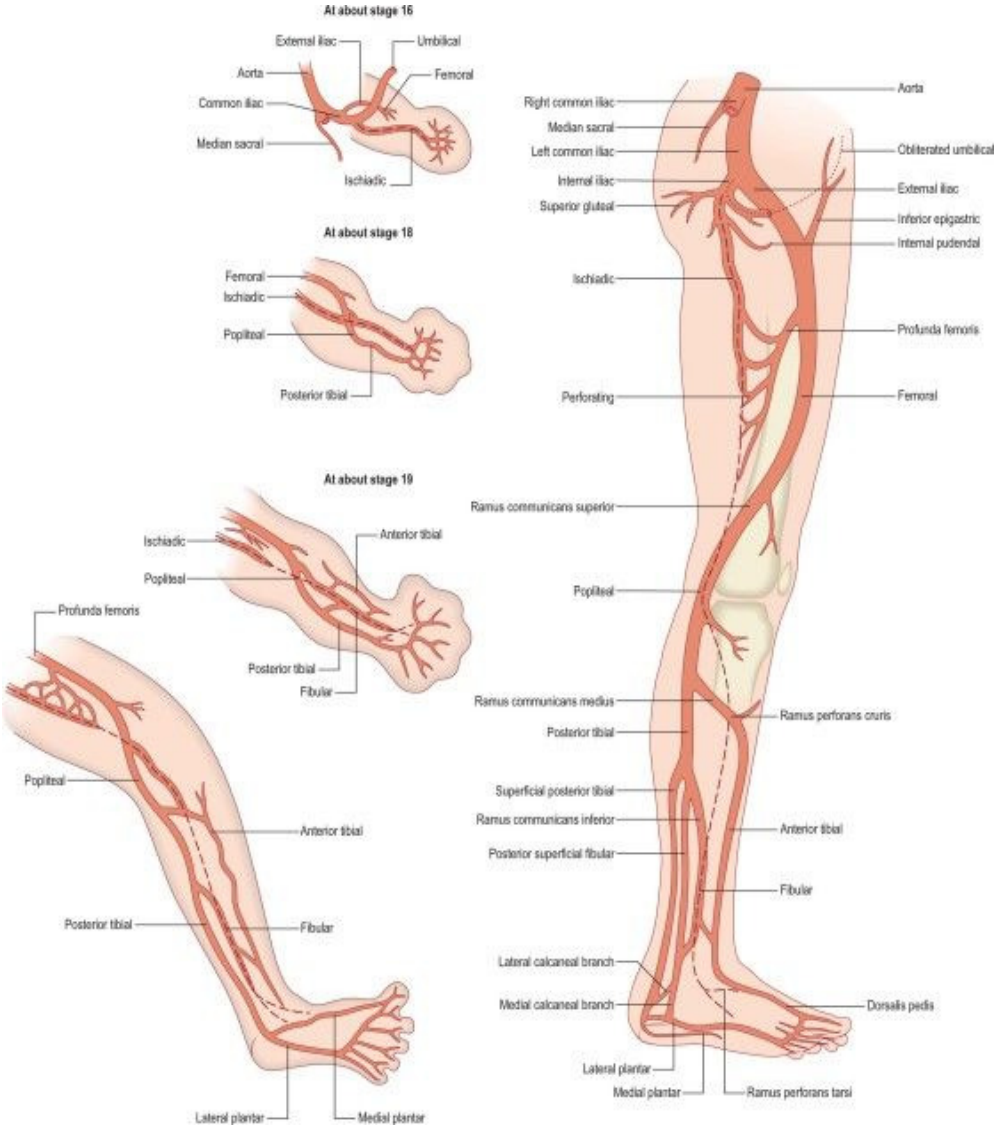
The arterial system of the lower limb develops from the axial artery of the lower limb. The dorsal root of the umbilical artery gives rise to the axial artery which descends along the dorsal surface of the thigh, knee and leg . The artery lies between the tibia and popliteus below the knee, and it lies between the crural interosseous membrane and tibialis posterior in the leg. A perforating artery is given off from the axial artery, which traverses the sinal tarsus to form a dorsal network. The axial artery then ends distally in a plantar network.

The femoral artery descends along the ventral surface of the thigh, and this opens a new vascular channel to the lower limb. It arises from a capillary plexus which is connected with the femoral branches of the external iliac artery proximally and with the axis artery distally. The axis artery splits into primitive posterior tibial and fibular branches at the proximal border of popliteus .These branches run distally on the dorsal surface of popliteus and tibialis posterior to enter the sole of the foot. A perforating branch is given off at the distal border of popliteus. This branch passes ventrally between the tibia and the fibula and then descends to the dorsum of the foot, forming the anterior tibial and dorsalis pedis arteries. The primitive fibular artery

communicates with the axis artery at the distal border of popliteus and in its course in the leg.

As femoral artery gradually increases in size, most of the axis artery disappears. The axis artery proximal to its communication with the femoral artery persists as the inferior gluteal artery and the arteria comitans nervi ischiadici.

DEVELOPMENT OF FEMORAL ARTERY



Materials and Methods

MATERIALS AND METHODS

STUDY MATERIALS:

1) 50 adult lower limb specimens
2) 25 adult femoral angiograms
3) 10 CT(Computerised tomographic) angiograms of femoral artery

METHOD OF STUDY:

1) Conventional dissection method
2) Radiological study

SPECIMEN COLLECTION:

1) Adult lower limb specimens were obtained from the embalmed cadavers allotted for routine academic dissections to the first year MBBS and BDS students at the Institute of Anatomy, Madras Medical College, Chennai.
2) 25 adult femoral angiograms were collected irrespective of the patient particulars from the Barnard Institute of Radiology, Rajiv Gandhi Government General Hospital, Chennai.
3) 10 CT angiograms of femoral artery obtained from the Barnard Institute of Radiology.

CONVENTIONAL DISSECTION METHOD:

A horizontal incision from the anterior superior iliac spine to the pubic tubercle was made along the inguinal ligament. This incision was extended down, along the external genitalia and lower down vertically along the medial border of the thigh. It was further extended along the medial side of the knee, down to the legs till the level of the tibial tuberosity. From this point, another horizontal incision was made laterally and the skin flap was reflected from medial to lateral side.

The superficial fascia was exposed and the superficial branches of the FA were dissected, their origin and course observed. The superficial circumflex iliac artery was found to course towards the lateral part of the groin. The superficial external pudendal artery arose medially to supply the external genitalia. The superficial epigastric artery was found to ascend towards the anterior abdominal wall crossing the IL. The superficial veins were found to accompany their corresponding arteries.

The deep fascia was reflected, and the GSV draining in to the femoral vein , through the anterior wall of the femoral sheath was dissected and exposed. The femoral sheath was split laterally and the FA was exposed. The sartorius and the adductor longus which form the boundaries of the femoral triangle, were exposed till the apex of the triangle where they meet. The femoral artery was exposed completely throughout its course in the femoral

triangle. The DEPA was found to arise from the upper part of the FA and coursed medially towards the external genitalia.

The profunda femoris artery was found to arise from the FA about 3-4 cm below the IL. The distance of the origin of the PFA from the MIP was measured using a measuring tape. The lateral and medial circumflex arteries were dissected , their site of origin and the branching pattern were identified.

The middle third of sartorius was lifted laterally which exposed a narrow strip of fascia forming the roof of adductor canal between vastus medialis and the adductor muscles. This fascia was divided longitudinally and the femoral vessels were identified.

The DGA was found to arise just above the opening in the adductor magnus .The osseoaponeurotic opening in the adductor magnus was identified and the continuation of FA as popliteal artery was observed.

During the above dissection, the origin of the FA in relation to the MIP and the relation between the FA and FV in the femoral triangle were noted, and branches of the FA dissected and photographed for documentation.

The origin of the FA in relation to the mid inguinal point was measured as follows: The distance between the ASIS and the PS was measured with a measuring tape. This was marked as the inguinal distance. The midpoint of this

line was taken as the MIP. Similarly the distance between the PS and the origin of the FA, the point where it crossed the inguinal ligament was measured with a measuring tape. This was taken as the femoral distance. Then the total number of cases where the location of the femoral artery coincided with the MIP was noted.

RADIOLOGICAL STUDY:

25 adult femoral angiograms and 10 CT angiograms of the femoral artery were obtained from archives of Barnard Institute of Radiology and the FA and its branches were studied.

Observation

Fig. 1 Femoral artery origin coinciding with mid inguinal point

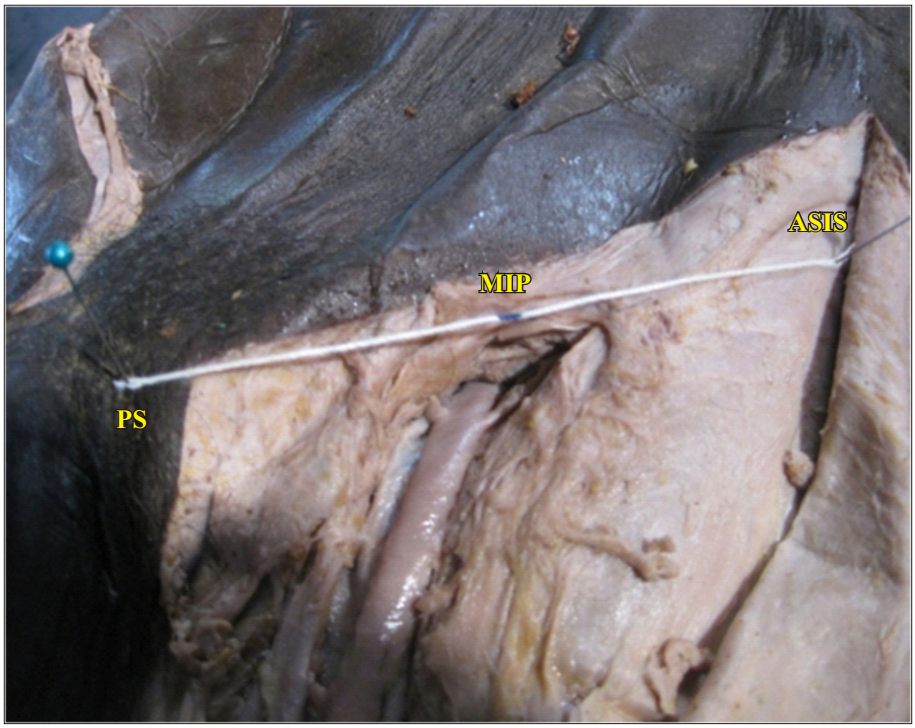
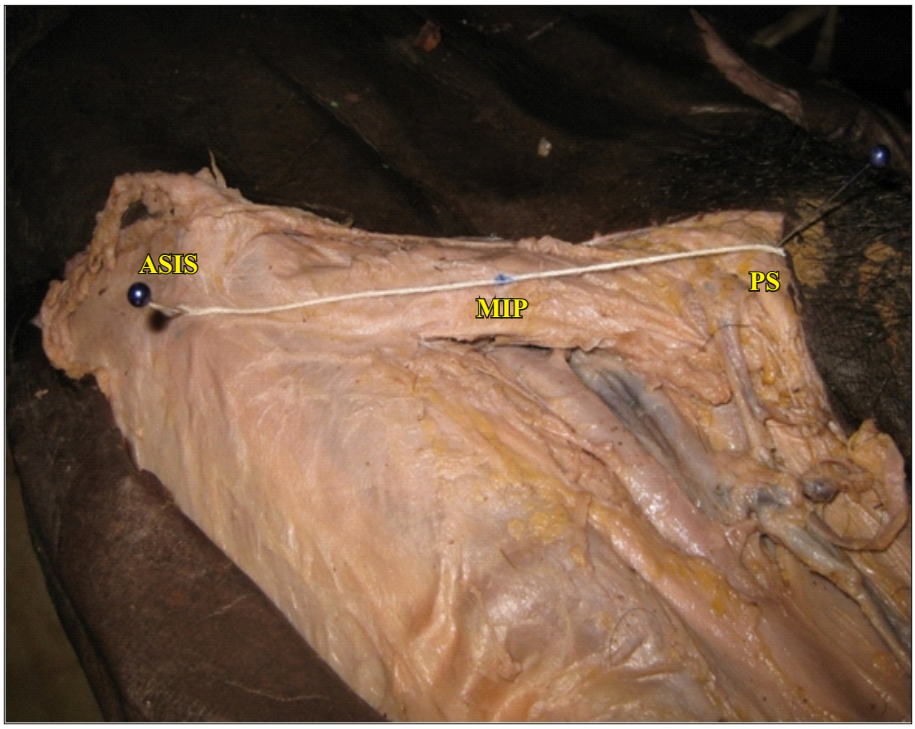


Fig.2 Femoral artery arising lateral to the mid inguinal point



OBSERVATION

ORIGIN OF FEMORAL ARTERY IN RELATION TO THE MID INGUINAL POINT

Of the 50 lower limb specimens dissected, in 44 cases(88%) the origin of the femoral artery coincided with the mid inguinal point.(Fig.1). In 6 cases (12%) the femoral artery origin was lateral to the mid inguinal point.(Fig.2)

Table-1 Origin of FA in relation to MIP (Measurement of MIP)

S. No	Distance between PS and ASIS(cm)	Mid point of the distance between PS and ASIS (cm) MIP	Distance of origin of FA from PS(cm)
1	14.4	7.2	7.2
2	14.4	7.2	7.2
3	16.6	8.3	8.3
4	16.6	8.3	8.3
5	13.8	6.9	6.9
6.	13.8	6.9	6.9
7	18	9	9.2 lateral
8	18	9	9.2 lateral
9	15	7.5	7.5
10	15	7.5	7.5
11	16.4	8.2	8.2

S. No	Distance between PS and ASIS(cm)	Mid point of the distance between PS and ASIS (cm) MIP	Distance of origin of FA from PS(cm)
12	16.4	8.2	8.2
13	14.2	7.1	7.1
14	14.2	7.1	7.1
15	15.6	7.8	7.8
16	15.6	7.8	7.8
17	16.8	8.4	8.4
18	16.8	8.4	8.4
19	14.4	7.2	7.6 lateral
20	14.4	7.2	7.6 lateral
21	15	7.5	7.5
22	15	7.5	7.5
23	16	8	8
24	16	8	8
25	14.8	7.4	7.4
26	14.8	7.4	7.4
27	14.2	7.1	7.1
28	14.2	7.1	7.1
29	16.4	8.2	8.2
30	16.4	8.2	8.2
31	18	9	9
32	18	9	9
33	17.6	8.8	9.1 lateral

S. No	Distance between PS and ASIS(cm)	Mid point of the distance between PS and ASIS (cm) MIP	Distance of origin of FA from PS(cm)
34	17.6	8.8	9.1 lateral
35	14.6	7.3	7.3
36	14.6	7.3	7.3
37	16.2	8.1	8.1
38	16.2	8.1	8.1
39	18.8	9.4	9.4
40	18.8	9.4	9.4
41	16	8	8
42	16	8	8
43	16.8	8.4	8.4
44	16.8	8.4	8.4
45	14.4	7.2	7.2
46	14.4	7.2	7.2
47	14	7	7
48	14	7	7
49	18	9	9
50	18	9	9

Table-2 Origin of FA in relation to MIP

Origin of the FA	Frequency	Percentage
At the MIP	44	88%
Lateral to MIP	6	12%

Chart-1 Origin of FA in relation to MIP

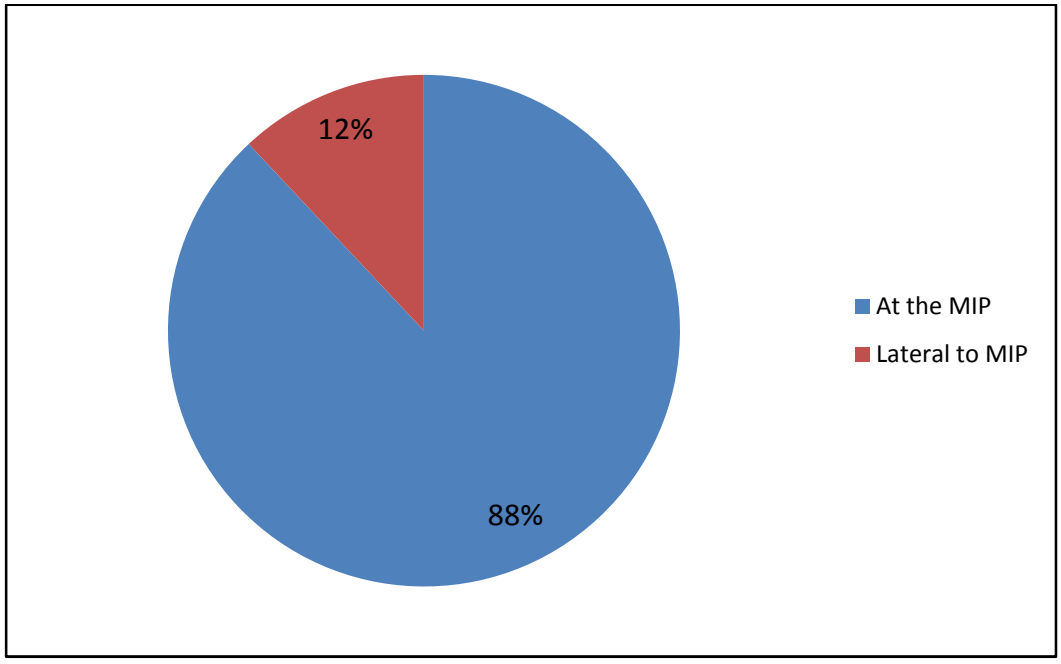


Fig.3 Femoral vein medial to the femoral artery in the upper part of femoral triangle

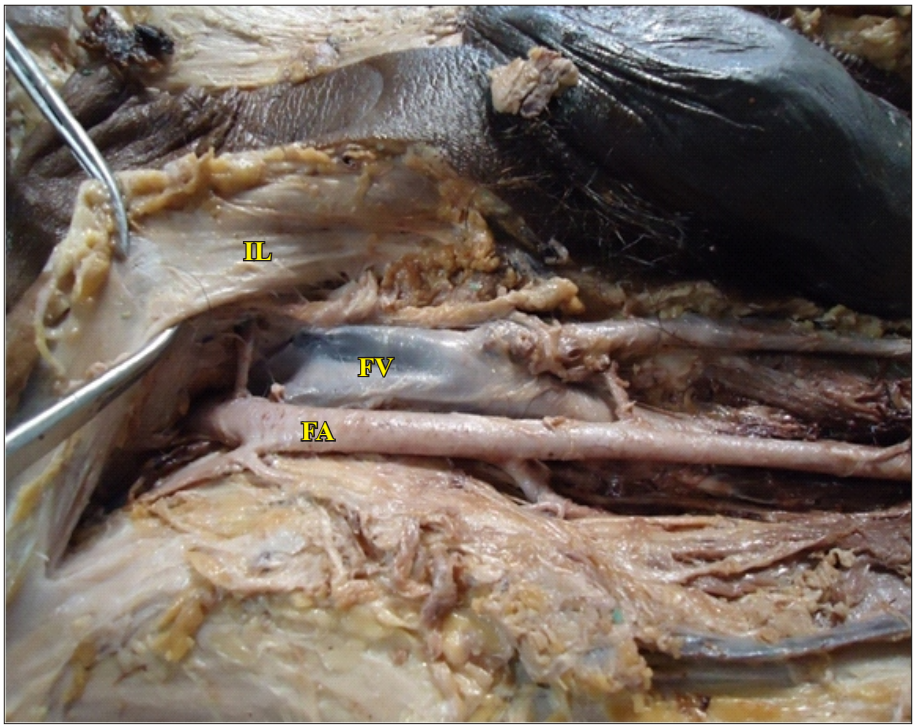
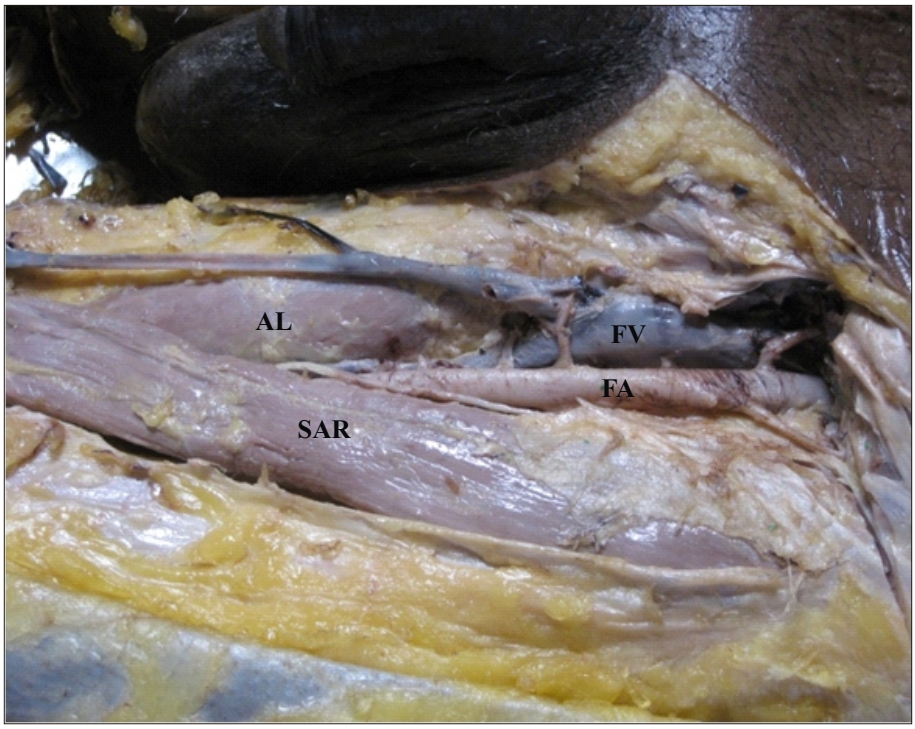


Fig.4 Femoral vein getting posterior to the femoral artery near the apex of the femoral triangle



RELATION OF THE FEMORAL ARTERY TO THE FEMORAL VEIN IN THE FEMORAL TRIANGLE

Out of 50 lower limb specimens studied, in all the specimens (100%) the femoral vein was found to lie medial to the femoral artery in the upper part of the femoral triangle, and went posterior to the femoral artery at the apex of the femoral triangle.(Fig.3 and 4)

In dissection done on a three month old infant in the Institute of Anatomy, Madras Medical College, the FA was seen traversing the femoral triangle, FV was medial to the FA, and the GSV was seen draining in to the FV. The branches of the femoral nerve were seen lateral to the FA.(Fig.5)

SITE OF ORIGIN OF SUPERFICIAL CIRCUMFLEX ILIAC ARTERY

Of the 50 cases studied, the SCIA was not present in 4 cases(8%), arose as a separate trunk from the FA in 46 cases (92%)-Fig.6 and 7.

Table-3 Origin of SCIA from FA

Origin of SCIA from FA	Frequency	Percentage
Absent SCIA	4	8%
Separate trunk	46	92%

Fig. 5 Infant dissection-Femoral artery in the femoral triangle, great saphenous vein seen draining in to the femoral vein

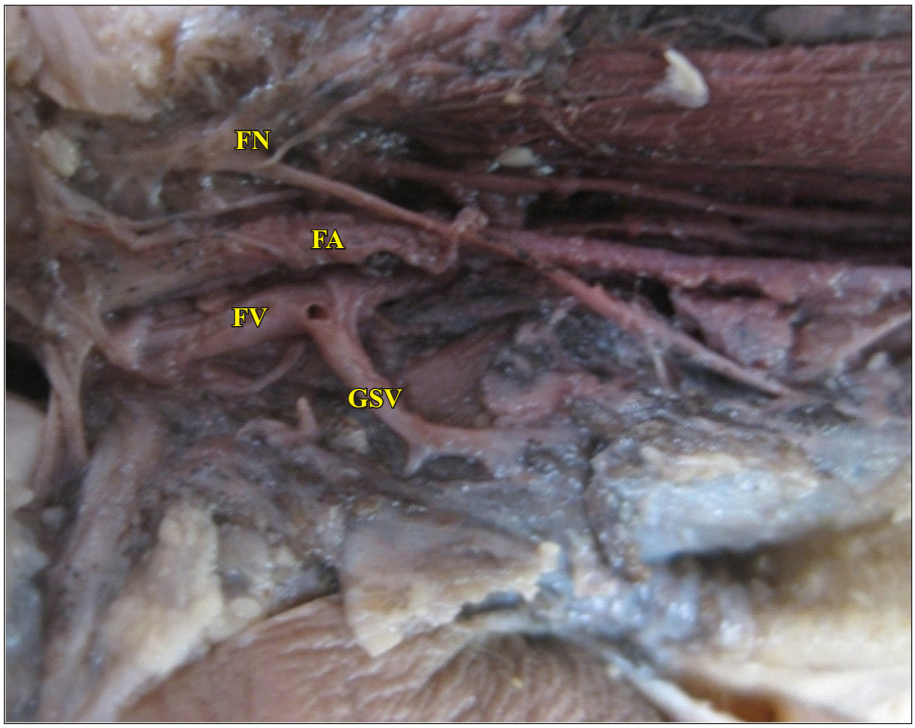


Fig.6 Superficial branches of the femoral artery in the femoral triangle.

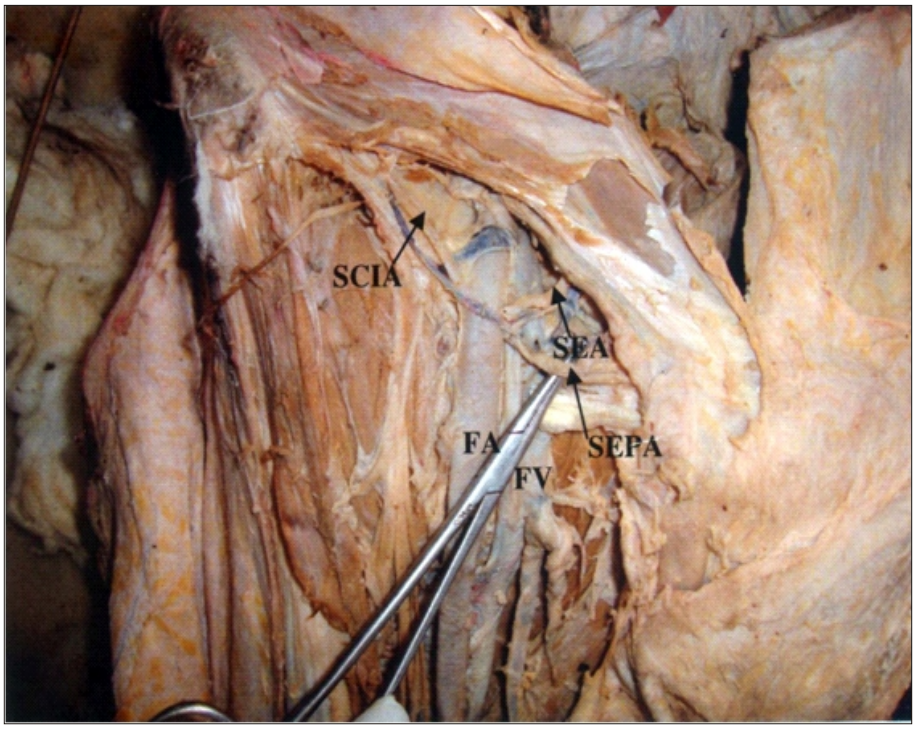
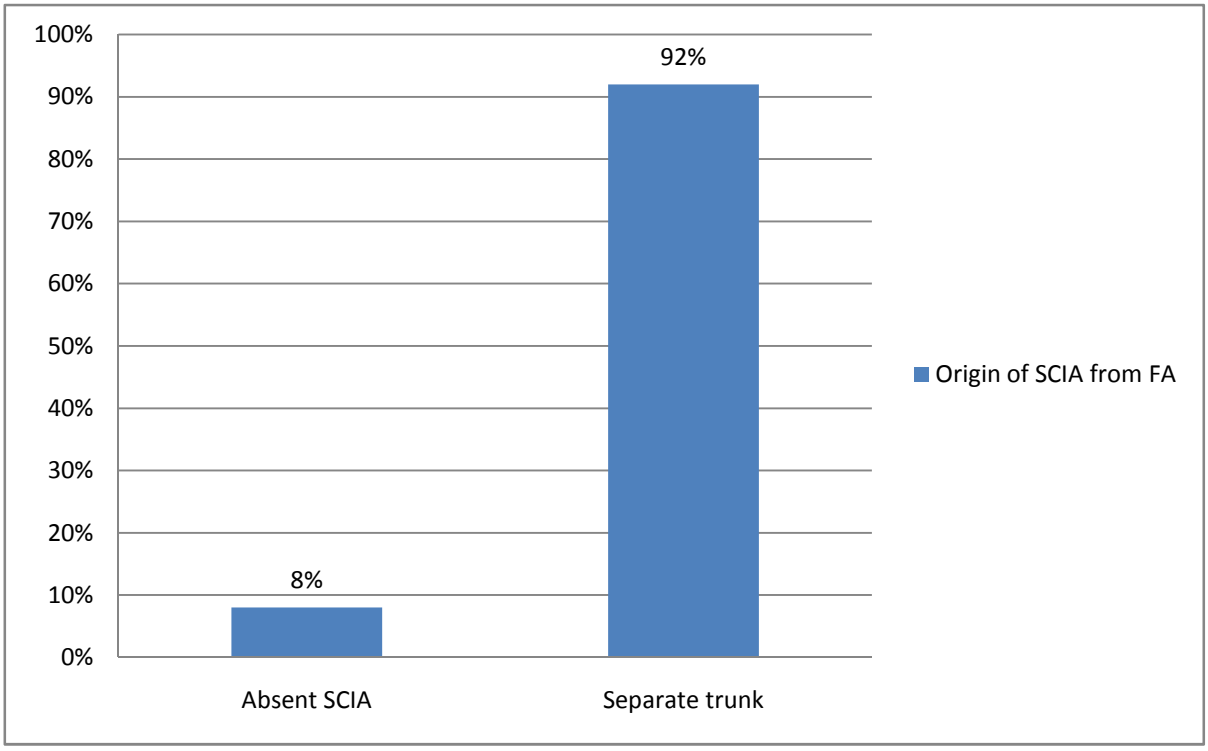


Chart-2 Origin of SCIA from FA



SITE OF ORIGIN OF SUPERFICIAL EPIGASTRIC ARTERY

Out of 50 lower limb specimens dissected, the SEA arose as a separate trunk from the femoral artery in 44 cases (88%)-Fig.6, as a common trunk with SEPA in 6 cases (12%)-Fig.8.

Table-4 Origin of SEA from FA

Origin of SEA from FA	Frequency	Percentage
As a separate trunk	44	88%
Common stem with SEPA	6	12%

Fig.7 Superficial circumflex iliac and superficial external pudendal arteries arising separately from the femoral artery

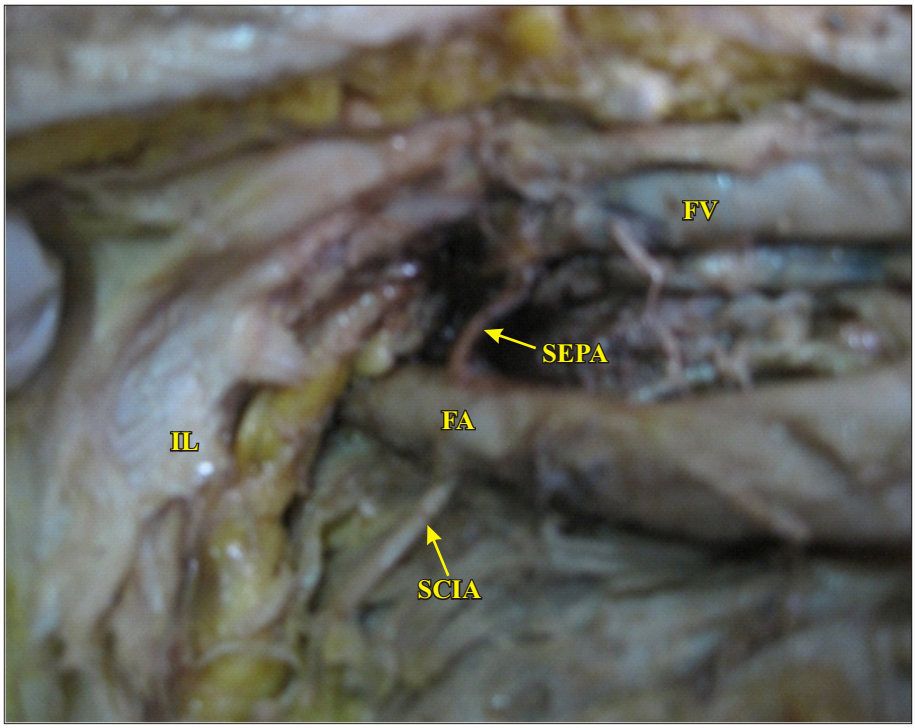


Fig.8 Superficial epigastric artery and superficial external pudendal artery arising as a common stem from femoral artery, SCIA absent

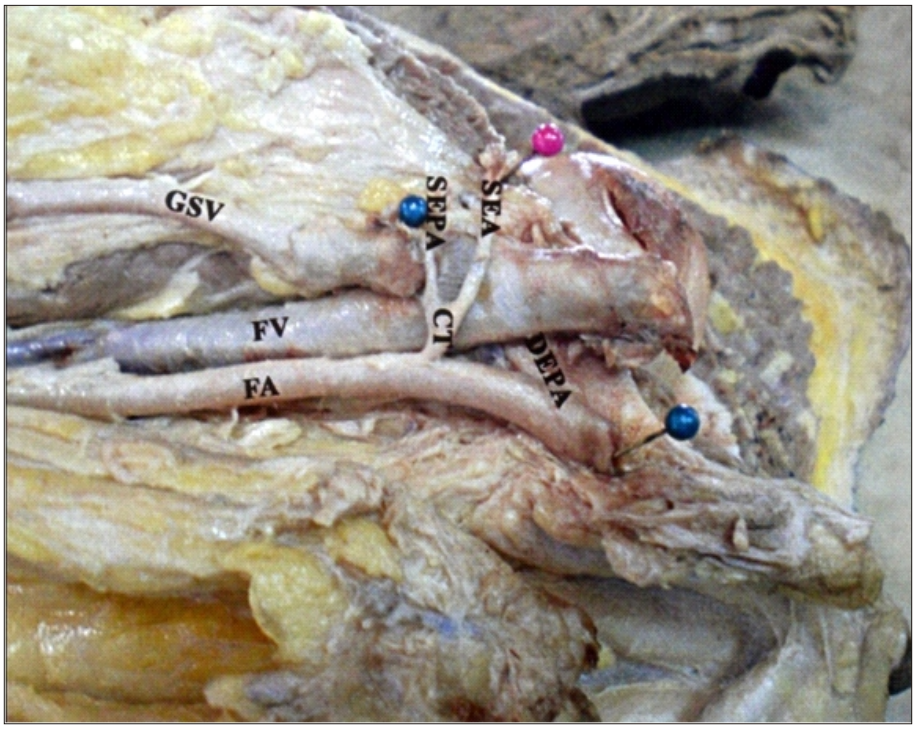
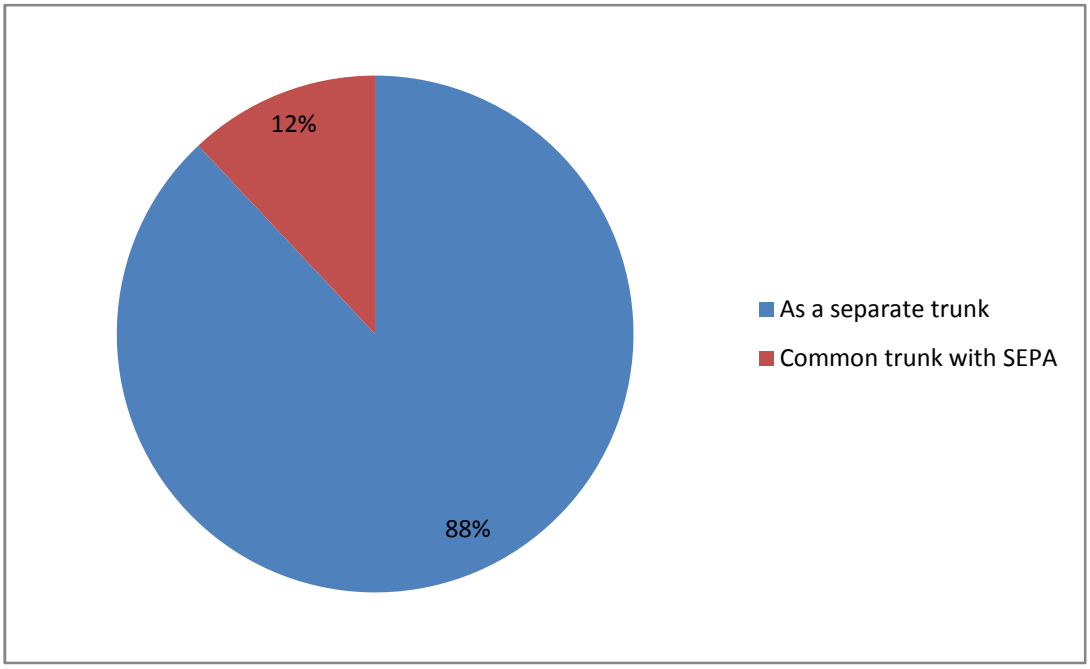


Chart-3 Origin of SEA from FA



SITE OF ORIGIN OF SUPERFICIAL EXTERNAL PUDENDAL ARTERY

Out of 50 specimens, the SEPA arose as a separate trunk from the FA in 40 specimens (80%)- Fig 6 and 7, arose as a common stem with SEA in 6 specimens (12%)-Fig.8, there was duplication of SEPA in 4 specimens (8%)-Fig.9.

Fig.9 Duplication of the superficial external pudendal artery

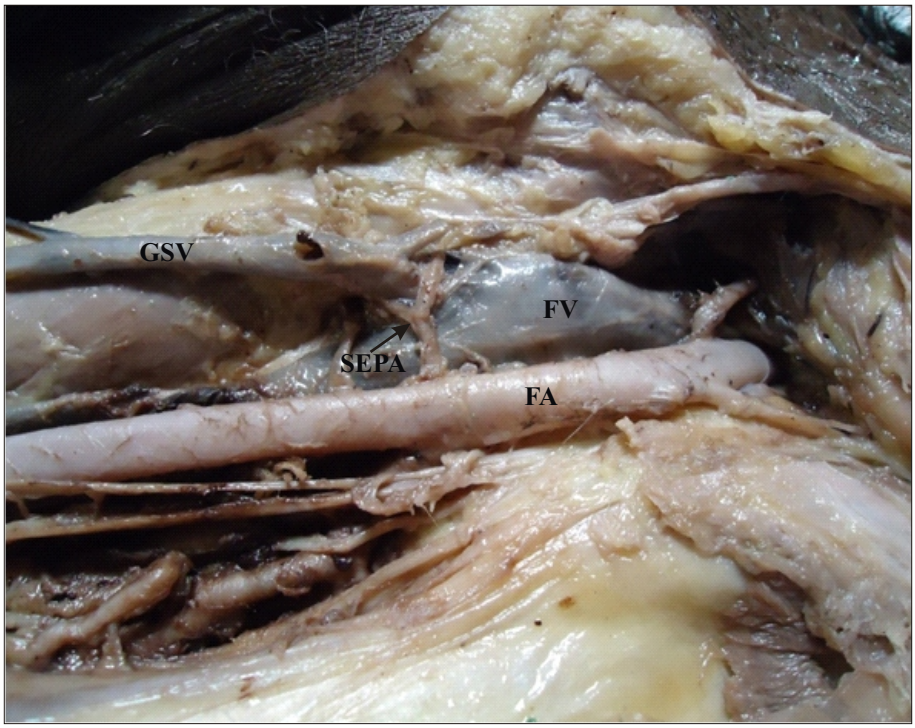


Fig.10 SEPA not visualized at the SFJ.SEPA arising above the SFJ

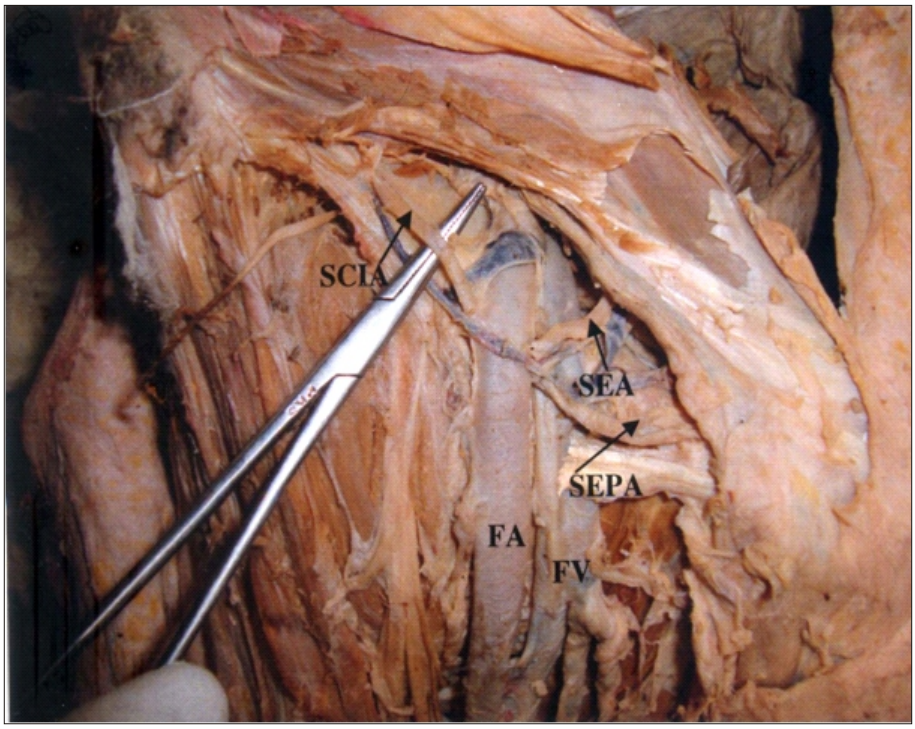


Table-5 Origin of SEPA from FA

Origin of SEPA from FA	Frequency	Percentage
Separate trunk	40	80%
Common stem with SEA	6	12%
Duplication of SEPA	4	8%

Chart-4 Origin of SEPA from FA

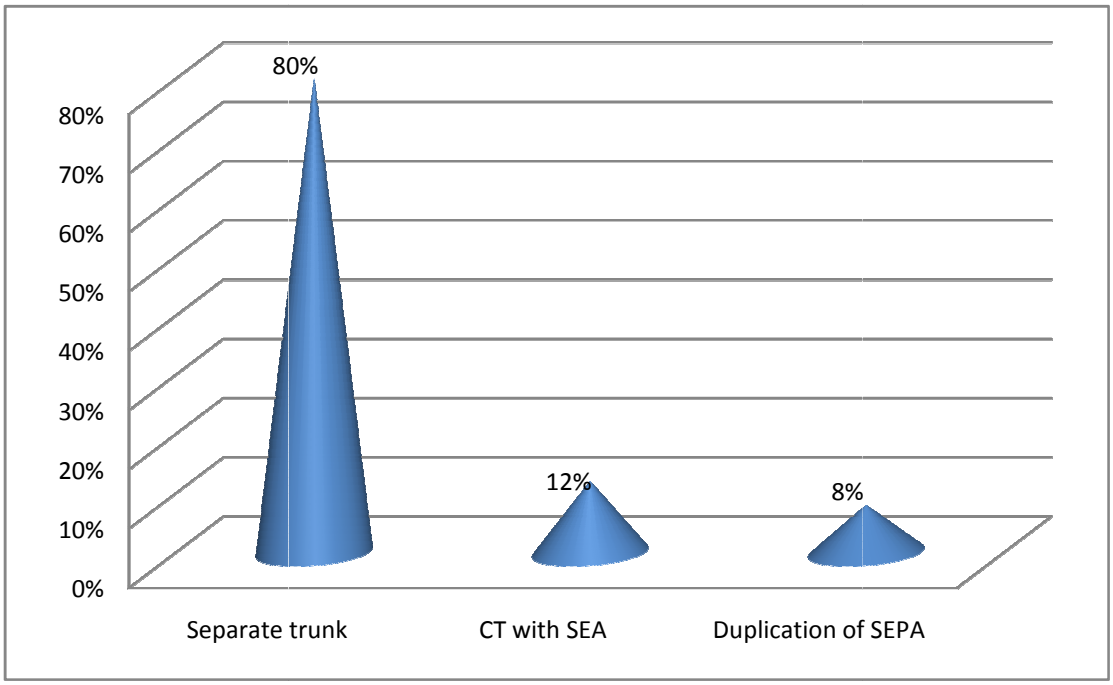


Fig.11 SEPA going anterior to the GSV

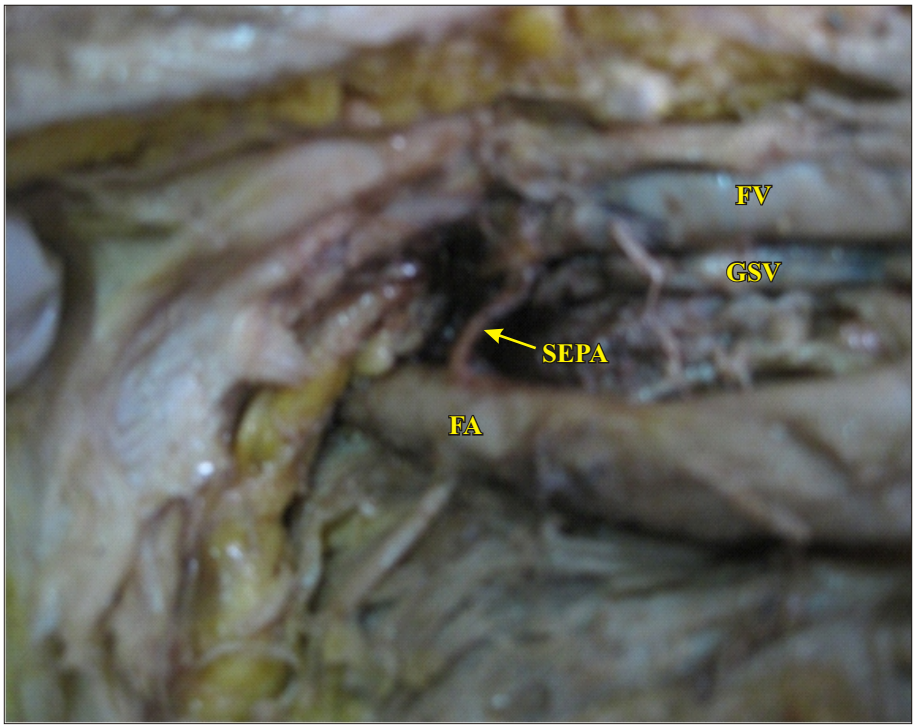
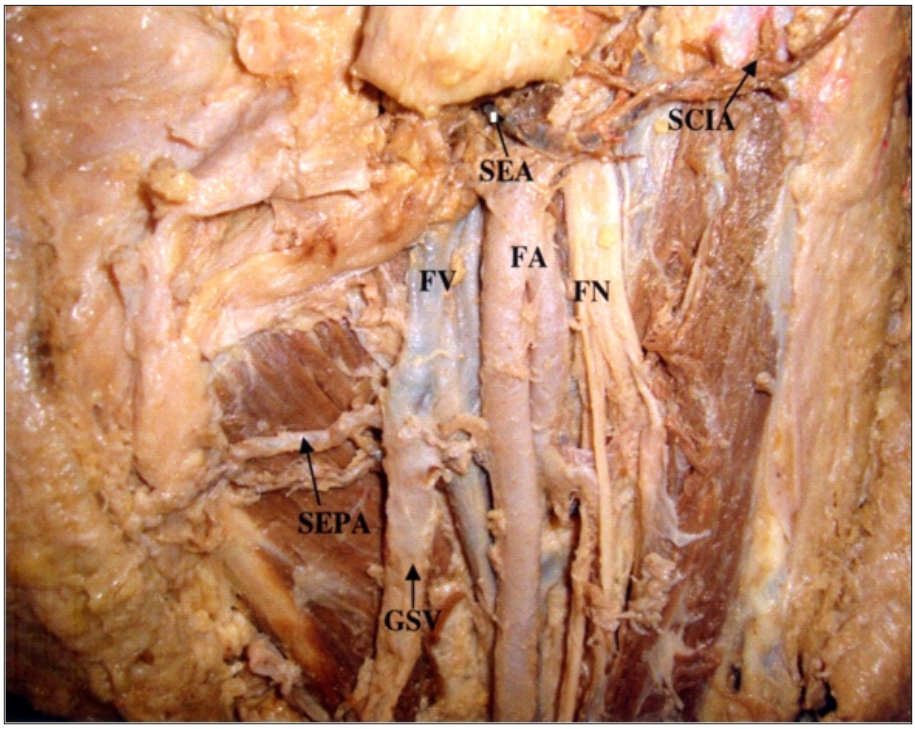


Fig.12 SEPA seen posterior to GSV



RELATION OF SUPERFICIAL EXTERNAL PUDENDAL ARTERY TO THE ARCH OF GREAT SAPHENOUS VEIN AT THE SAPHENOFEMORAL JUNCTION

Out of 50 cases, the SEPA was not visualized at the SFJ in 10 cases(20%)- Fig.10, went anterior to the GSV in 16 cases(32%)-Fig.11, and in 24 cases (48%) the SEPA went posterior to the GSV-Fig.12. In the 10 cases(20%), in which the SEPA was not seen at the SFJ, it was seen above the SFJ, close to the SEA and SCIA below the IL.

Table-6 Relationship of SEPA to GSV at the SFJ

Relationship of SEPA to GSV	Frequency	Percentage
SEPA not visualized at the SFJ	10	20%
SEPA anterior to GSV	16	32%
SEPA posterior to GSV	24	48%

Fig.13 DEPA arising from the medial side of the femoral artery

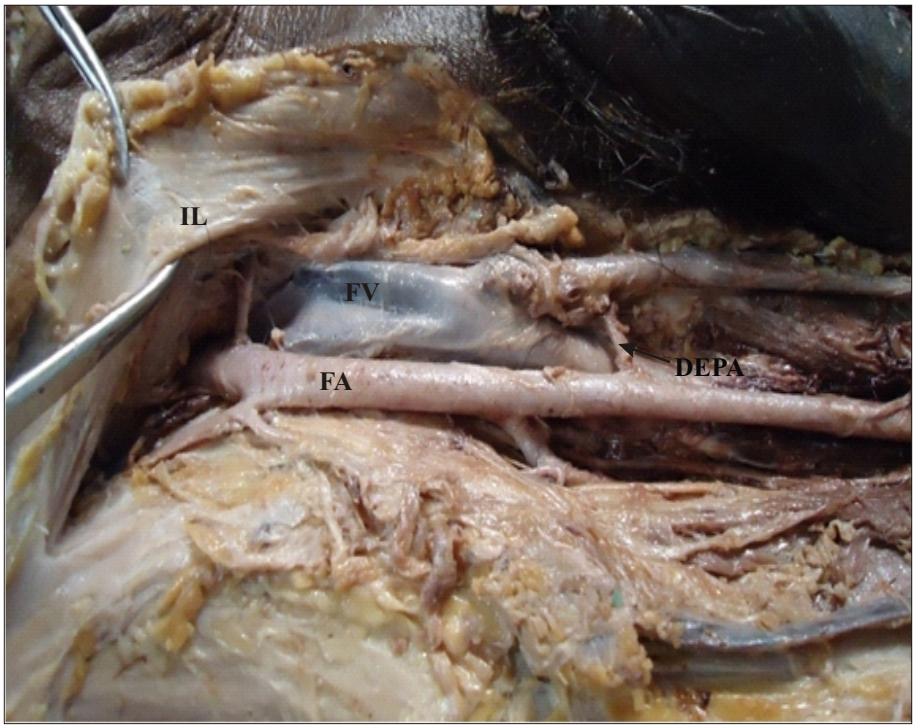


Fig.14 Deep external pudendal artery arising from the femoral artery, distal to the profunda femoris.

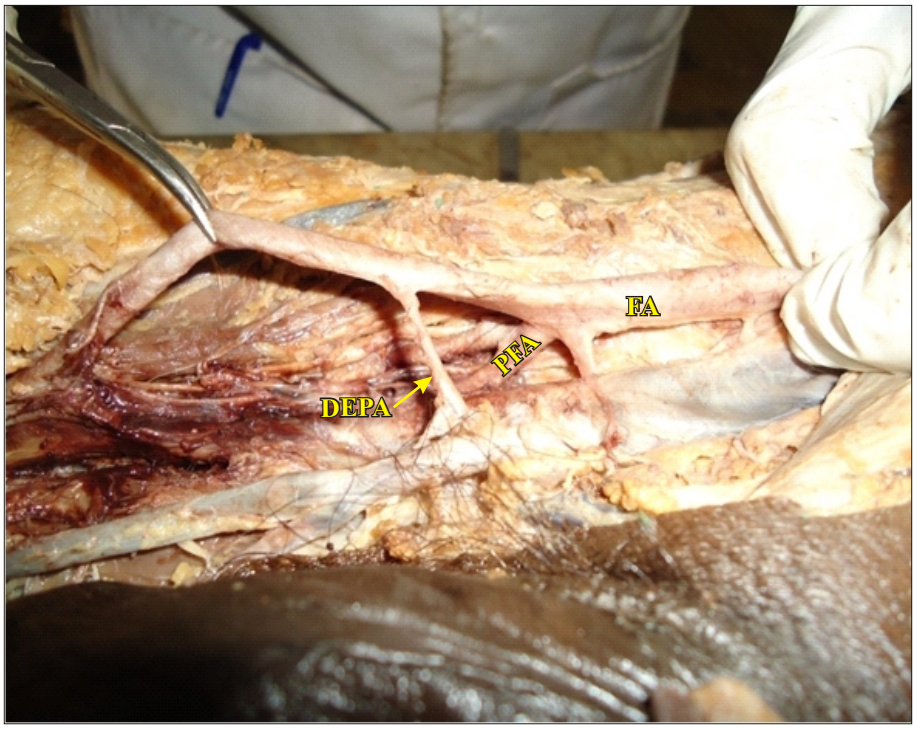


Fig.15 Profunda femoris artery arising from the posterolateral aspect of the femoral artery

Fig.16 Profunda femoris artery arising from the posterior side of the femoral artery

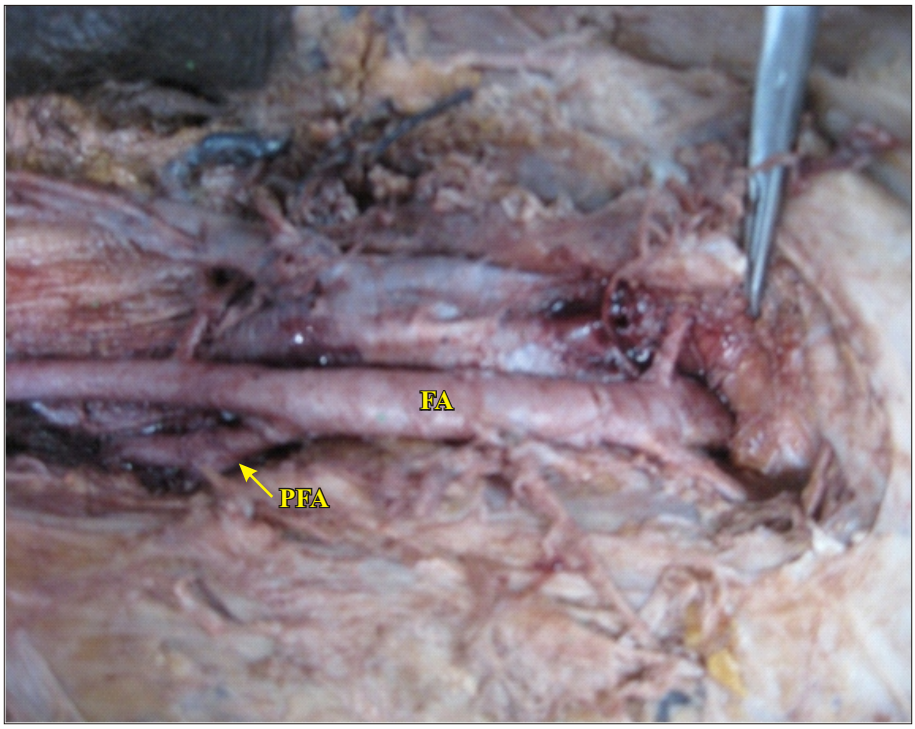
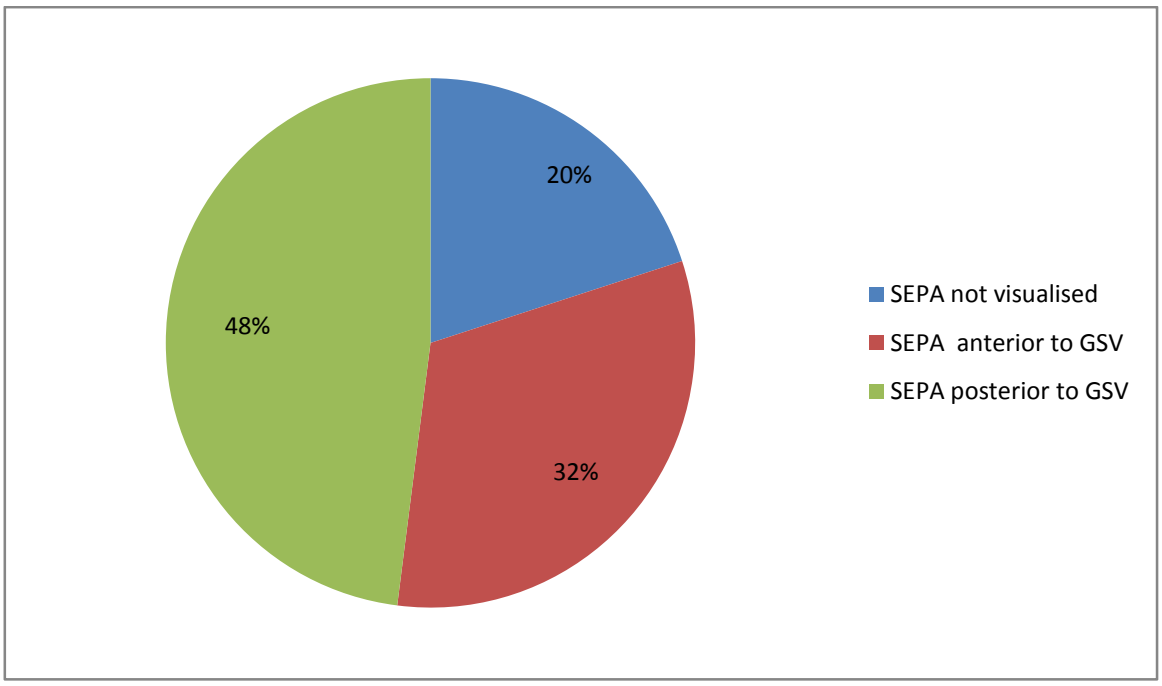


Chart-5 Relationship of SEPA to GSV at the SFJ



ORIGIN OF DEEP EXTERNAL PUDENDAL ARTERY

In all the 50 specimens studied, the deep external pudendal artery arose from the medial side of the femoral artery, proceeded medially towards the external genitalia(Fig.13). In 2 cases, the DEPA arose medially from the FA distal to the origin of PFA(Fig.14).

SITE OF ORIGIN OF PROFUNDA FEMORIS ARTERY

Out of 50 lower limb specimens dissected, the PFA was found to originate from the posterolateral aspect of the FA in 32 cases(64%)-Fig. 15, from the posterior side of the FA in 12 cases (24%)-Fig.16 from the lateral side in 6 cases (12%)-Fig.17.

Fig.17 Profunda femoris artery arising from the lateral side of the femoral artery

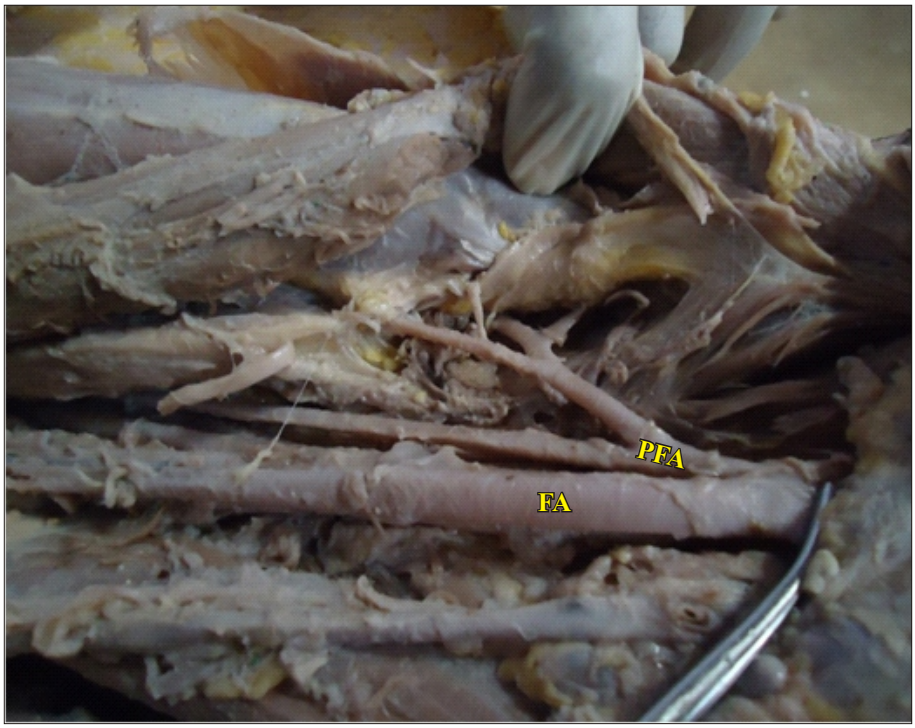


Fig..18 Measurement of distance of profunda femoris origin from the mid inguinal point

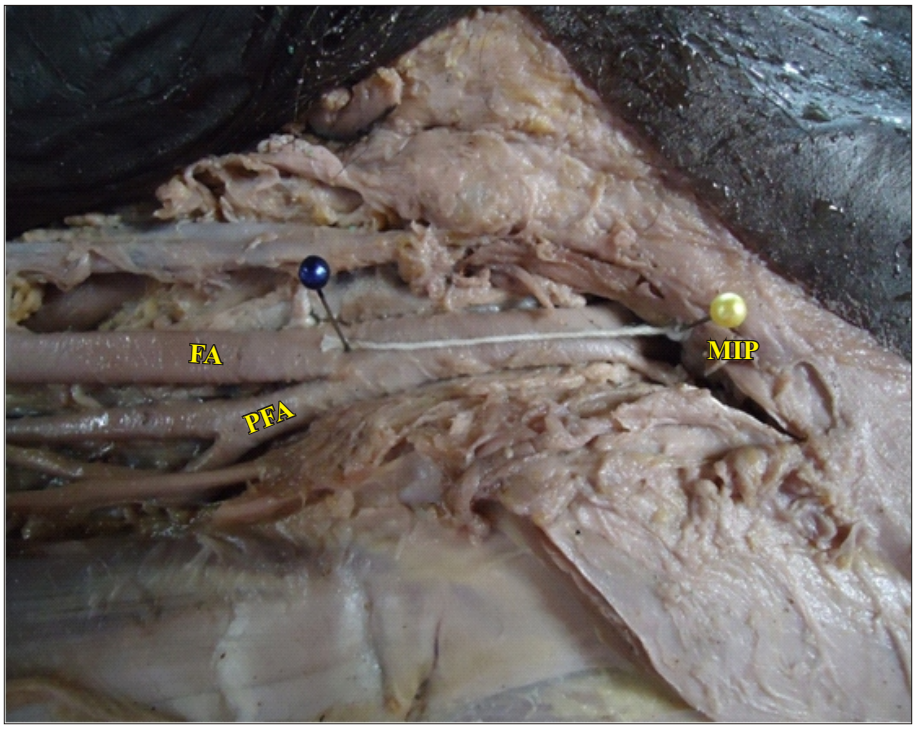


Table-7 Site of origin of PFA from FA

Site of origin of PFA	Frequency	Percentage
Postero lateral	32	64%
Posterior	12	24%
Lateral	6	12%

Chart-6 Site of origin of PFA from FA

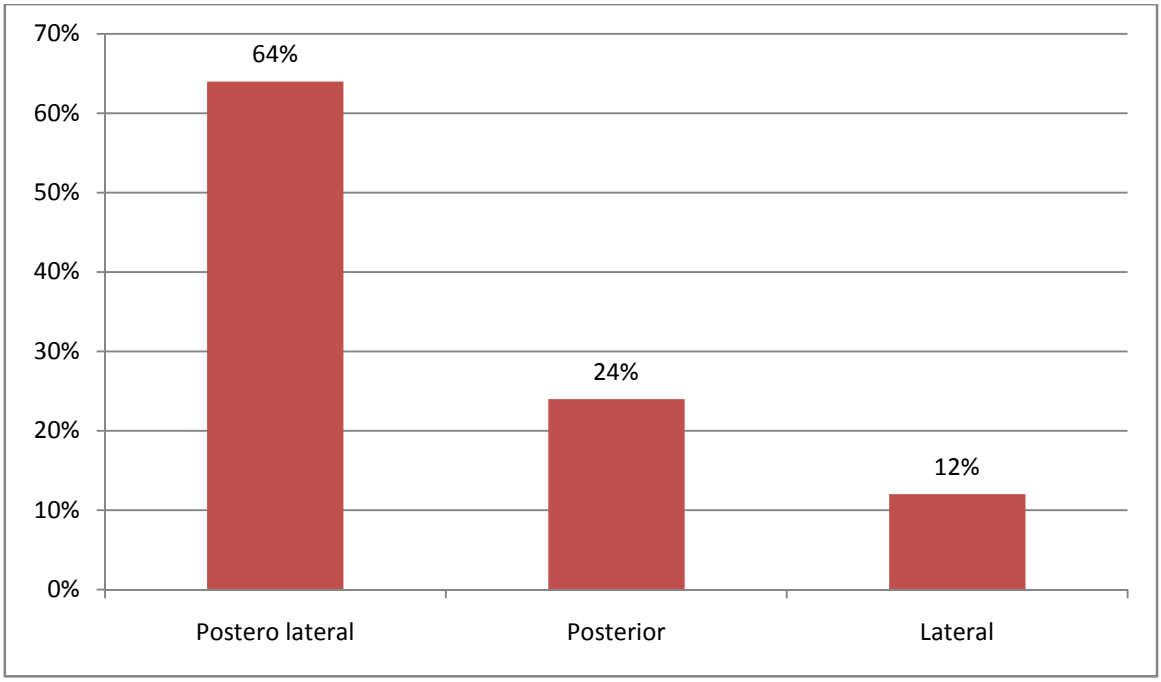


Fig.19 High origin of profunda femoris artery

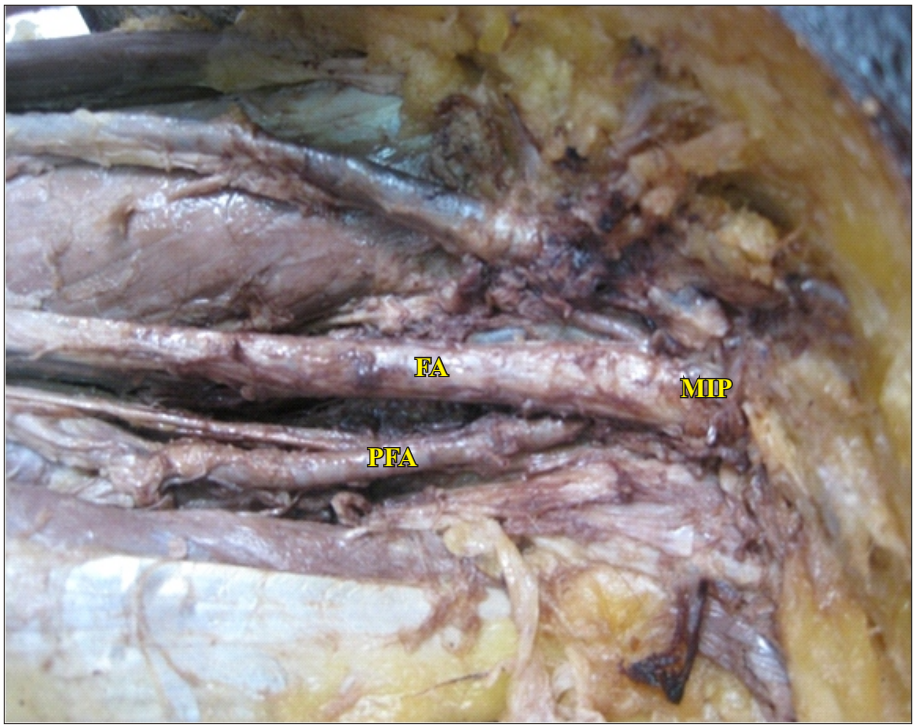


Fig.20 Origin of lateral circumflex femoral artery from profunda femoris

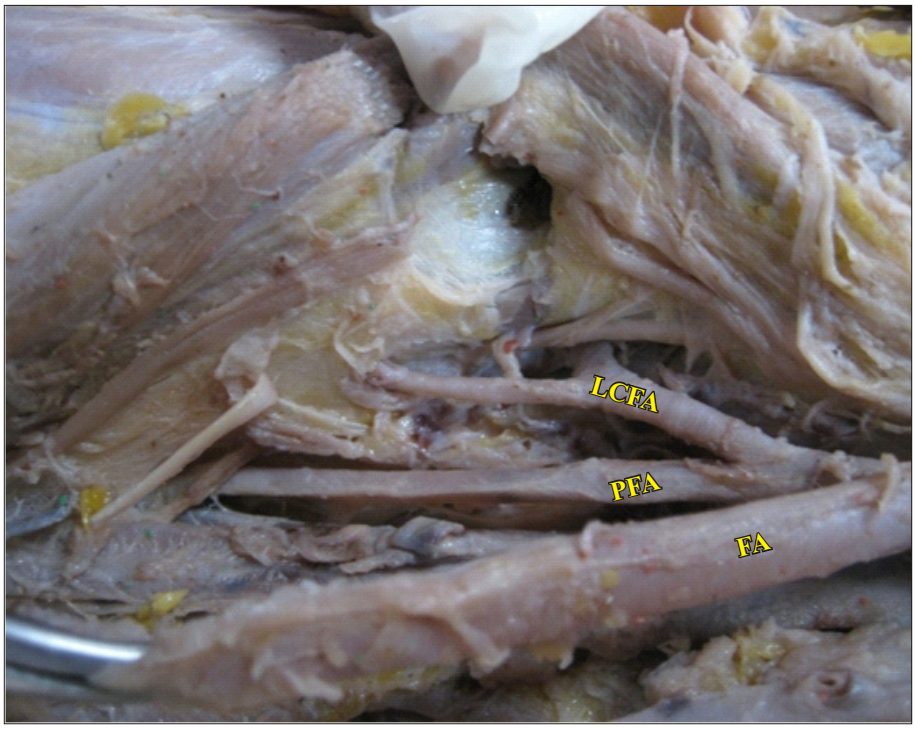


Fig.21 Lateral circumflex femoral artery dividing in to three branches after branching off from the profunda femoris artery

Fig..22 Lateral circumflex femoral artery arising from the femoral artery

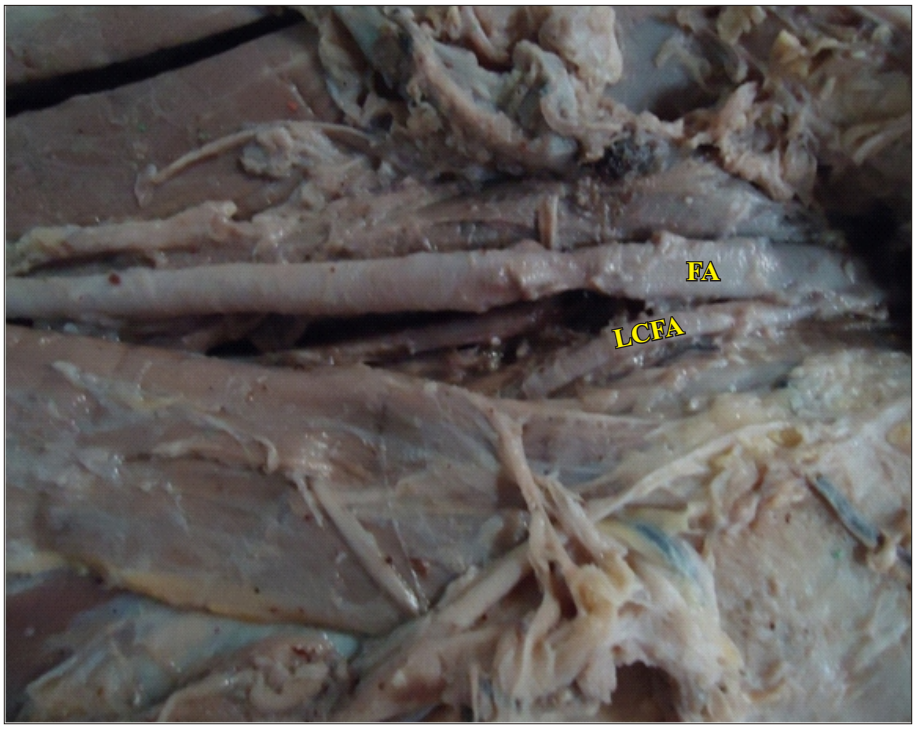


Fig.23(a) Lateral circumflex femoral artery arising as a common stem with profunda femoris artery

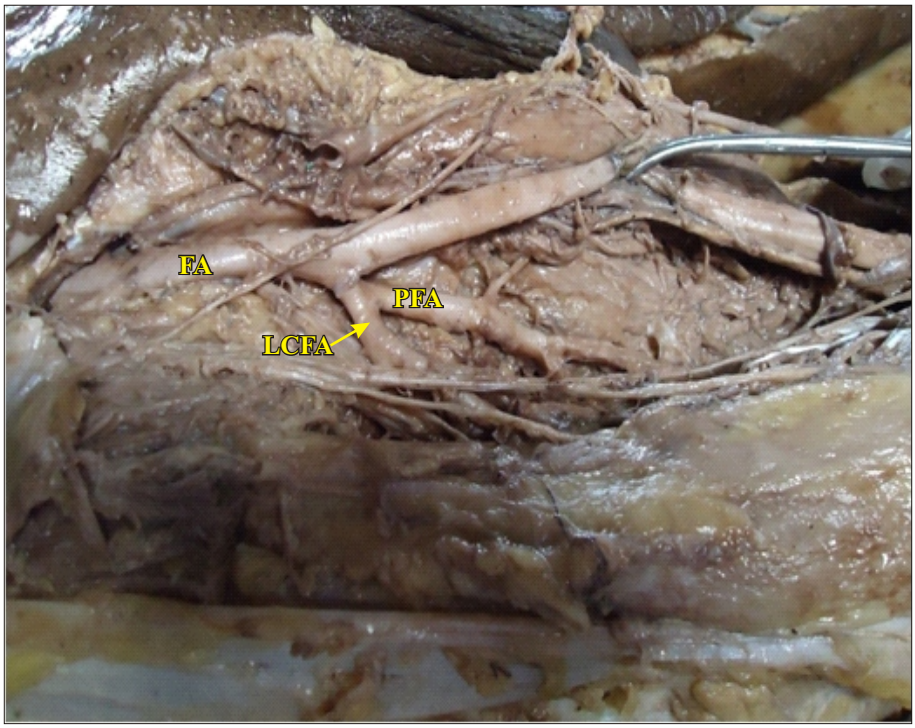
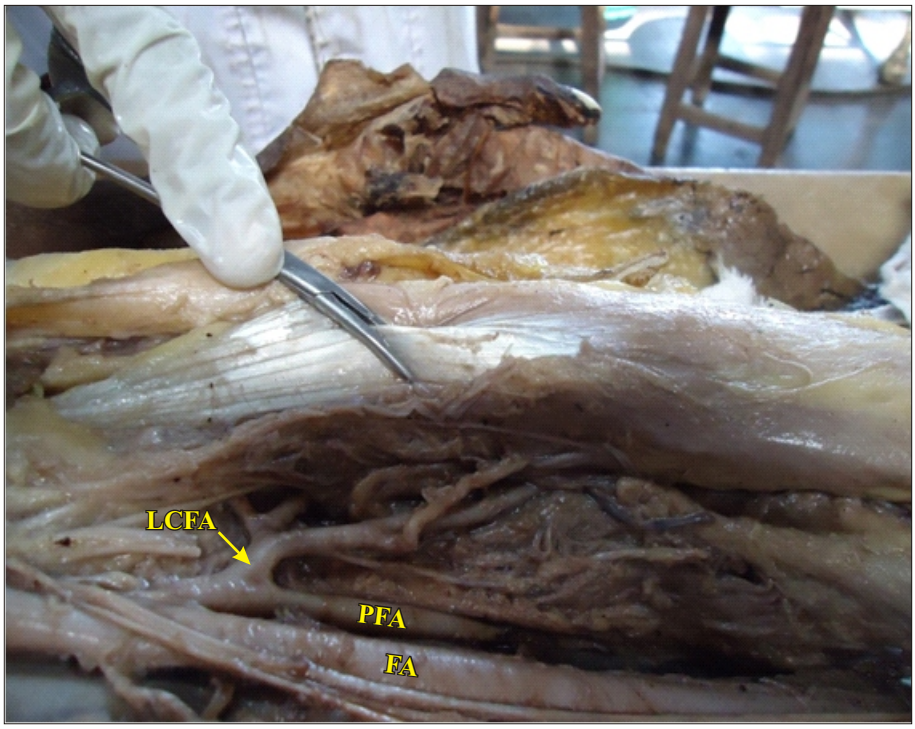


Fig.23(b) Lateral circumflex femoral artery arising as a common stem with profunda femoris artery



DISTANCE OF ORIGIN OF PROFUNDA FEMORIS ARTERY FROM THE MID INGUINAL POINT

The minimum length of the PFA origin from the MIP was 2 cm. Maximum length was 5.4cm. Mean length was found to be 4.31cm (Fig.18).

In 2 cases(4%) there was high origin of PFA which arose at a distance of 2 cm from the MIP (Fig19).

Table-8 Distance of origin of PFA from MIP

Minimal length	2.0cm
Maximal length	5.4cm
Mean length	4.31cm

SITE OF ORIGIN OF LATERAL CIRCUMFLEX FEMORAL ARTERY

Out of 50 specimens, the LCFA originated from the PFA in 36 specimens (72%)-Fig.20, with normal branching pattern (Fig.21). The LCFA arose from the FA in 14 specimens (28%)-Fig.22.

Out of 14 specimens, in 4 cases(8%), the LCFA and the PFA arose as a CT from the FA (Fig.23a and 23b).

Fig.24 Three branches of the lateral circumflex femoral arising directly from the profunda femoris artery.

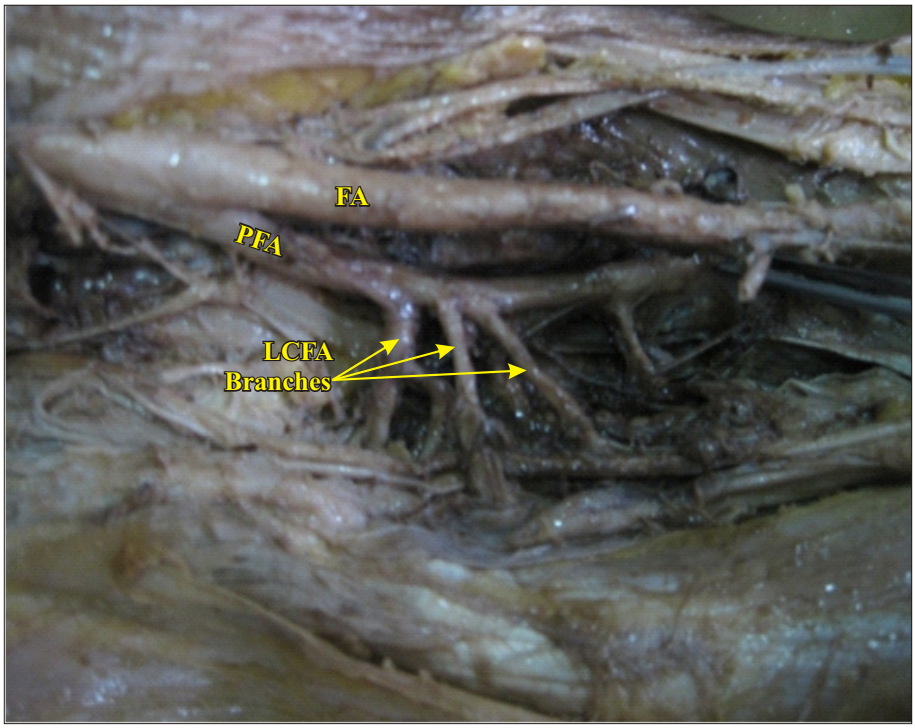
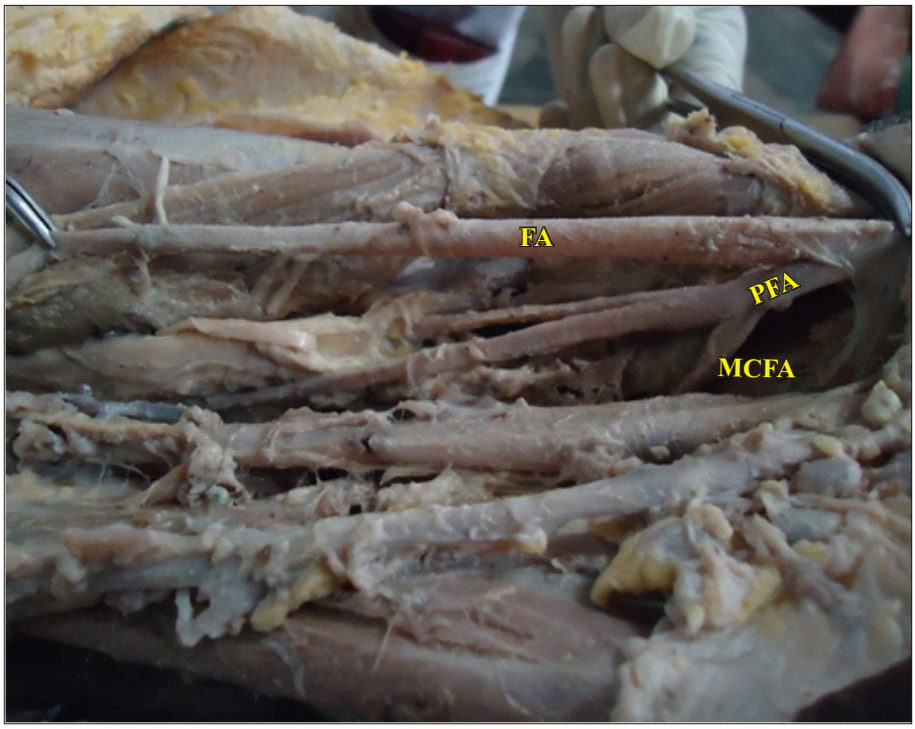


Fig.25 Origin of medial circumflex femoral artery from the profunda femoris artery



Out of 36 specimens, in 2 cases (4%) all the three branches of LCFA was arising directly from the PFA (Fig.24).

Table-9 Site of origin of LCFA

Origin of LCFA	Frequency	Percentage
From PFA	36	72%
From FA	14	28%

Chart-7 Site of origin of LCFA

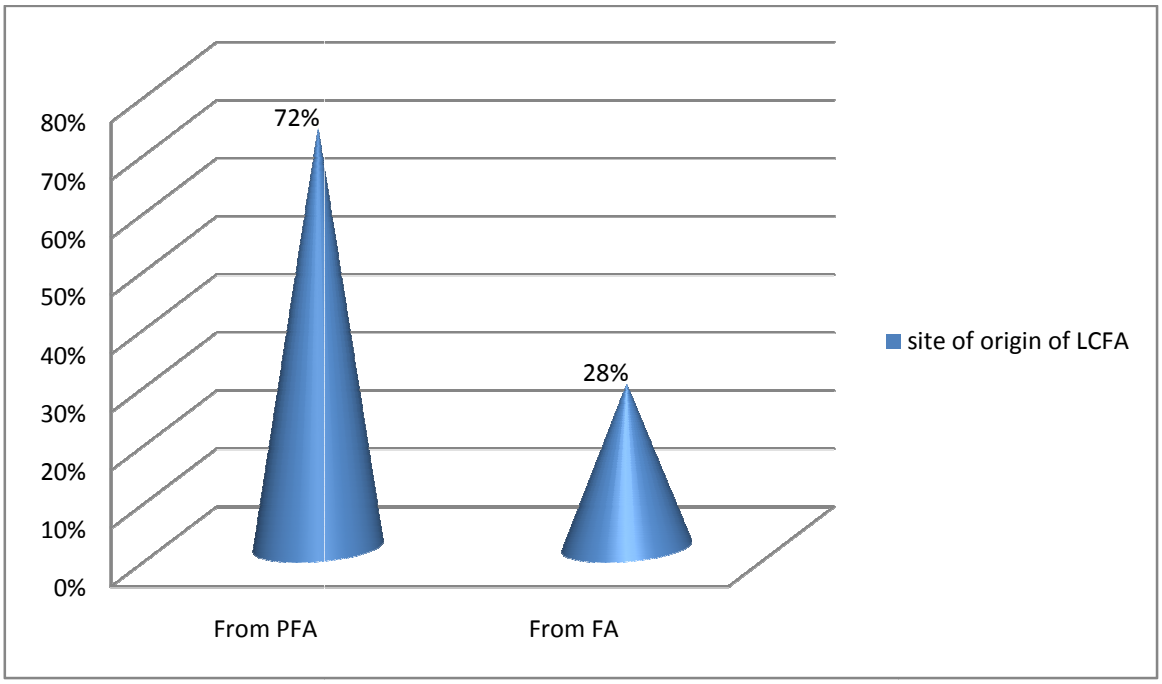


Table-10 Origin of LCFA from PFA-72%

Separate trunk from PFA	68%
Branches of LCFA arising directly from the FA	4%

Chart- 8 Origin of LCFA from PFA

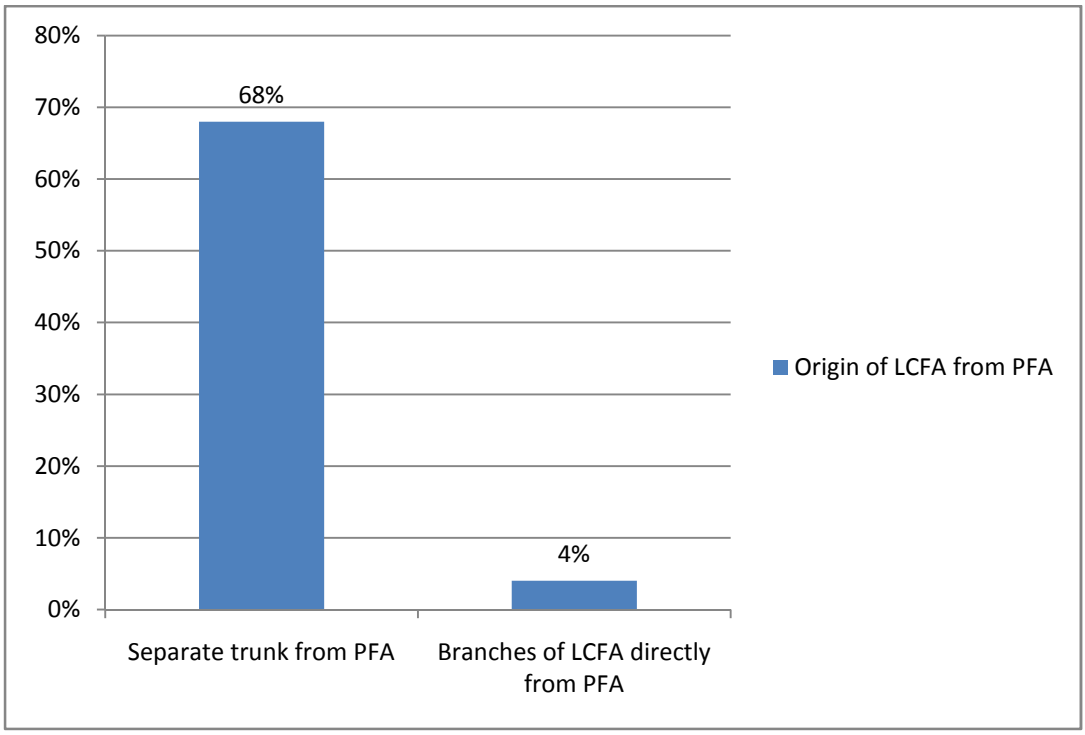


Table-11 Origin of LCFA from FA-28%

Separate trunk from FA	20%
CT with PFA	8%

Chart -9 Origin of LCFA from FA

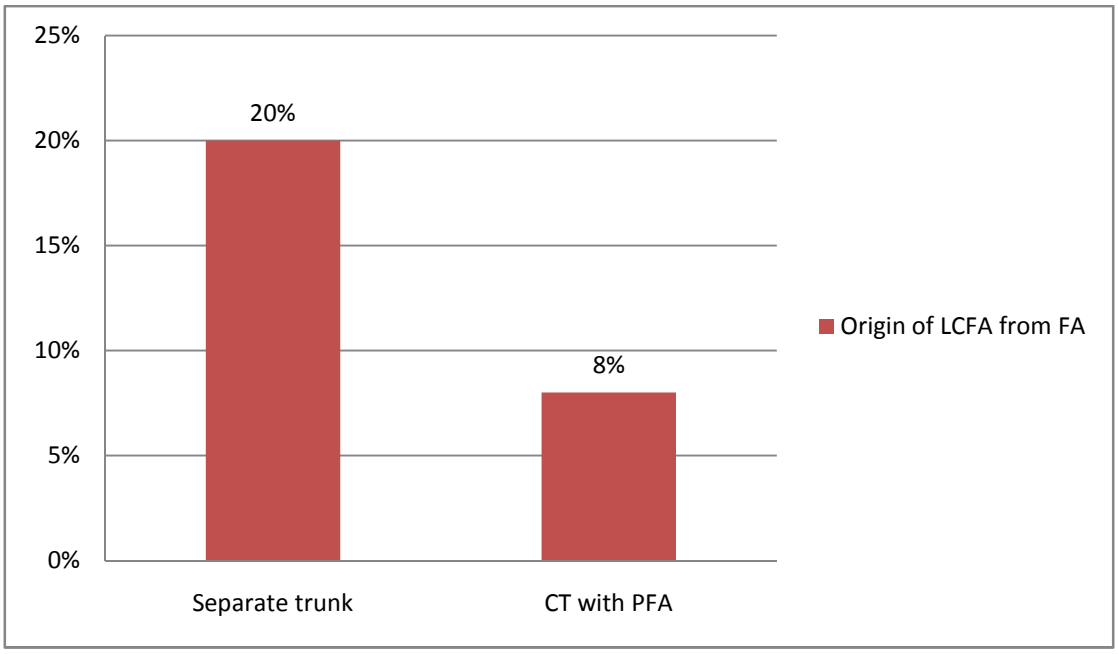


Fig.26(a) Medial circumflex femoral artery arising directly from the femoral artery

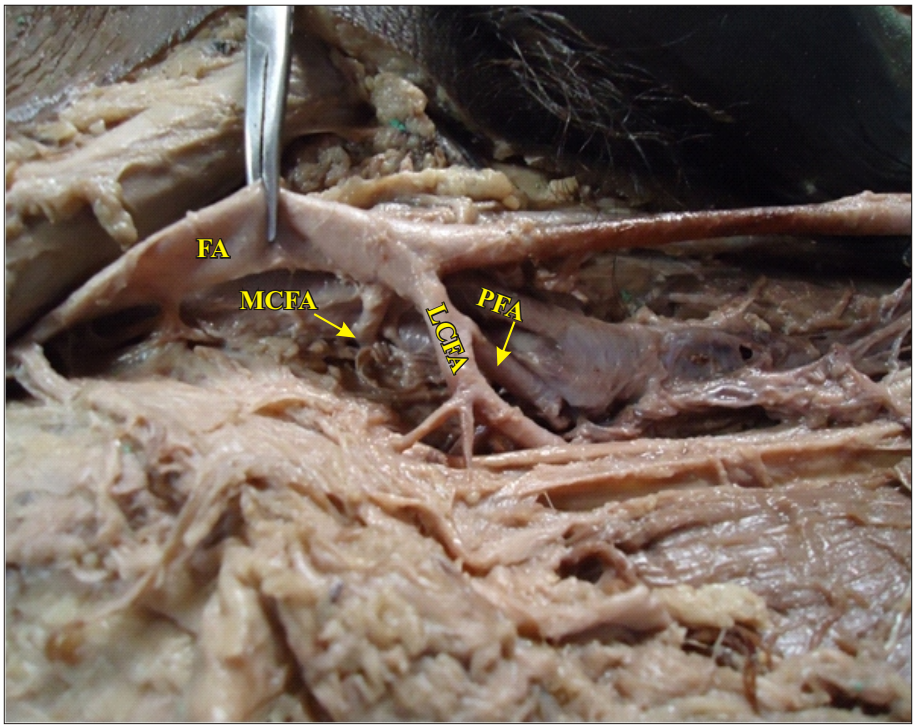
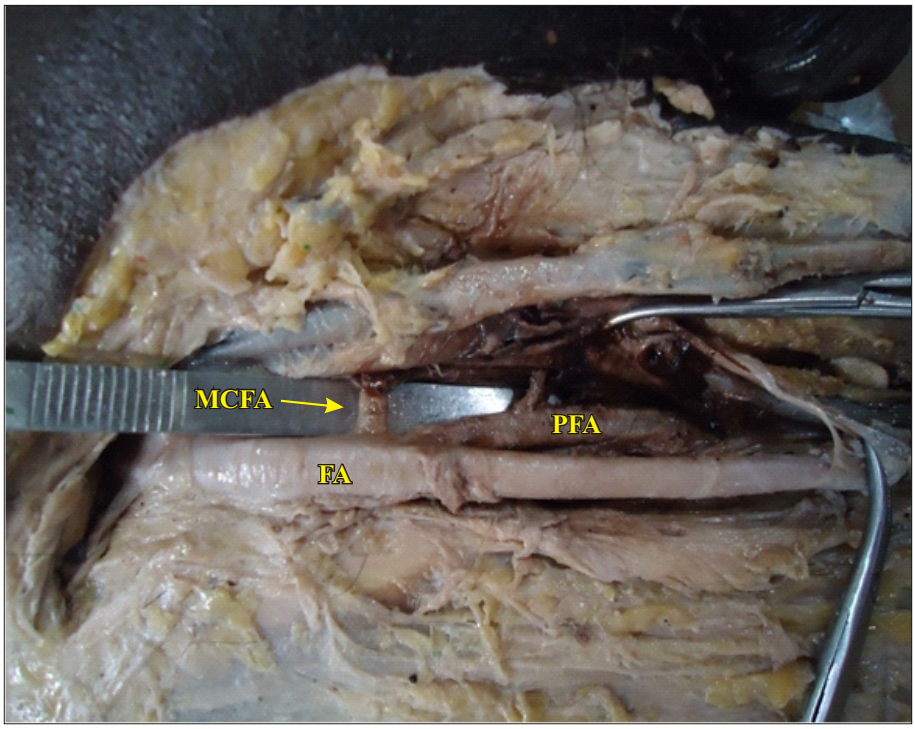


Fig.26(b) Medial circumflex femoral artery arising directly from the femoral artery



SITE OF ORIGIN OF MEDIAL CIRCUMFLEX FEMORAL ARTERY

Out of 50 specimens studied , the MCFA arose from the PFA in 32 cases (64%)-Fig.25, from the FA in 18 cases (36%)-Fig.26a and 26b.

In 2 cases (4%), the MCFA arose as a CT along with PFA (Fig.27).

Table-12 Site of origin of MCFA

Site of origin of MCFA	Frequency	Percentage
From PFA	32	64%
From FA	18	36%

Chart-10 Site of origin of MCFA

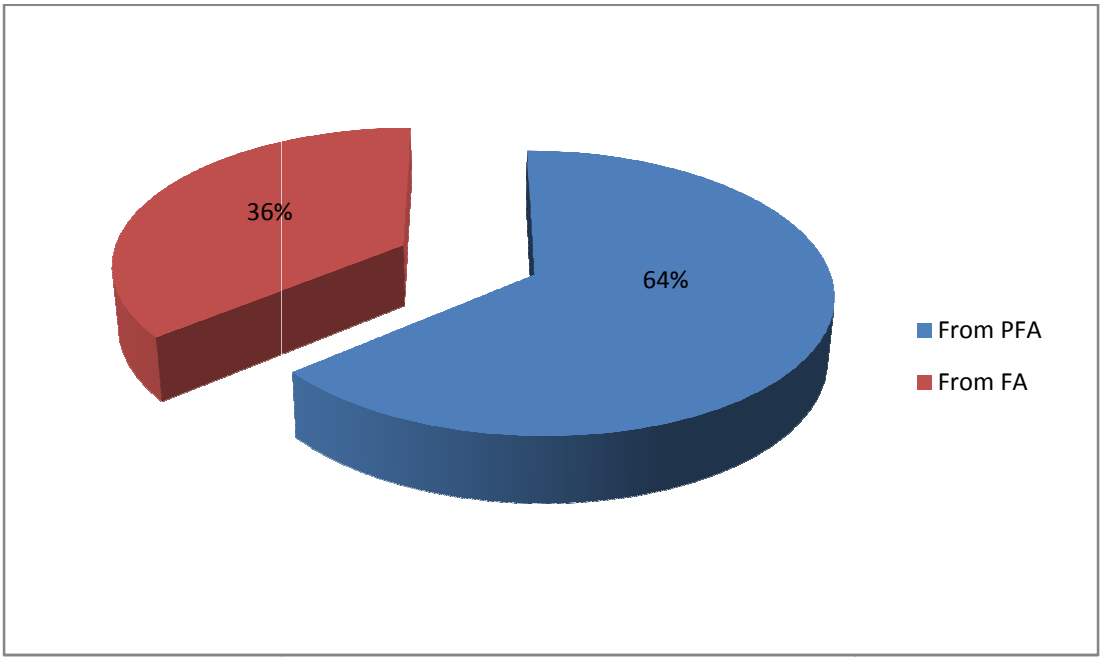


Fig.27 Medial circumflex femoral artery arising as a common stem with profunda femoris artery

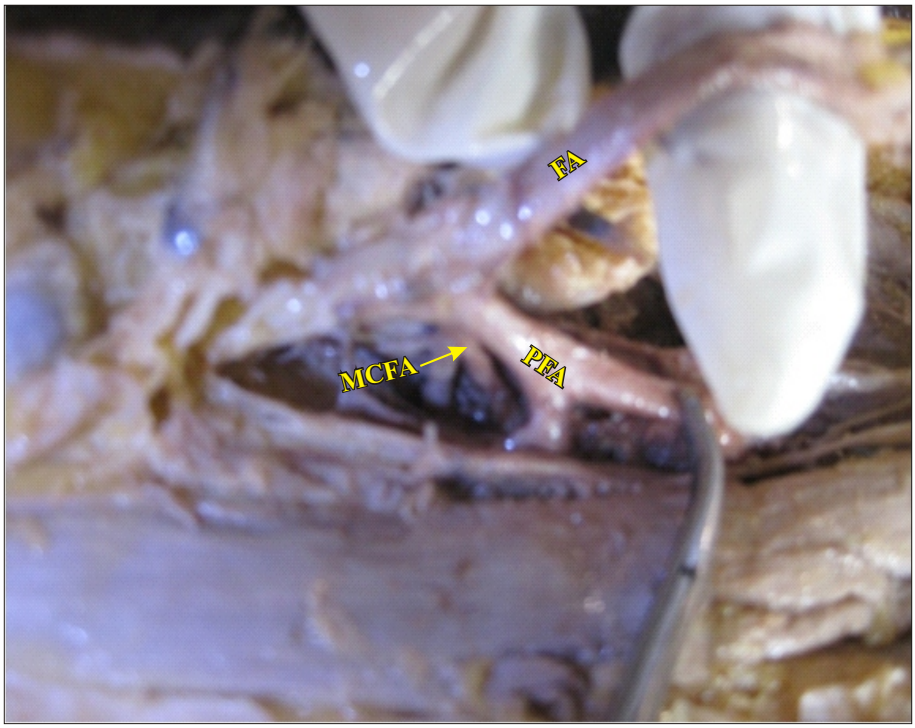


Fig. 28(a) Descending genicular artery arising from the femoral artery above the adductor opening.

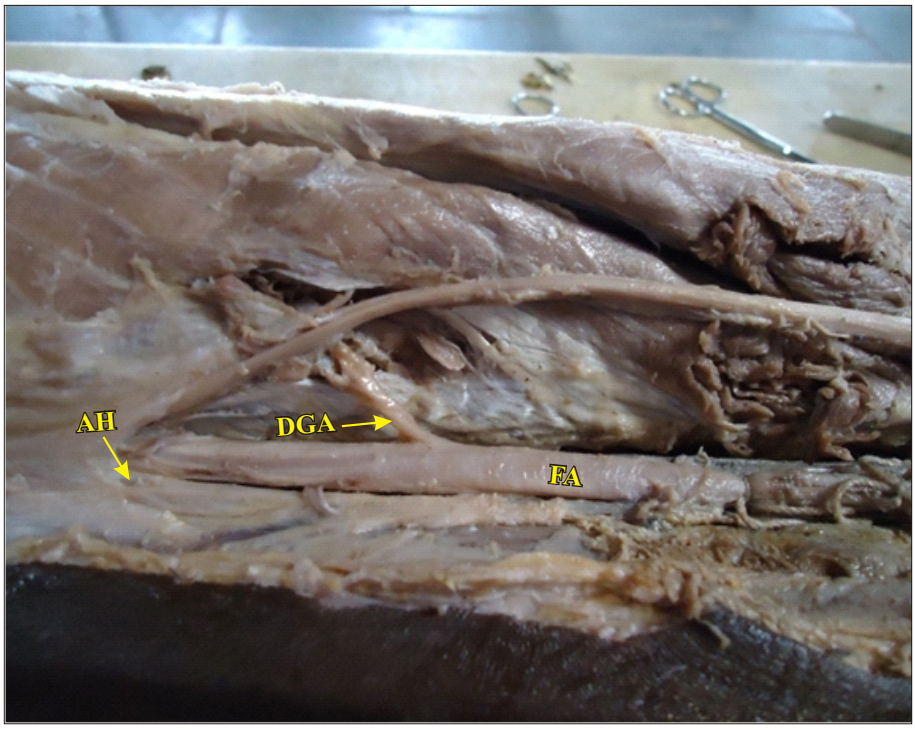


Table-13 Origin of MCFA from FA-36%

Separate trunk	32%
CT with PFA	4%

Chart -11 Origin of MCFA from FA

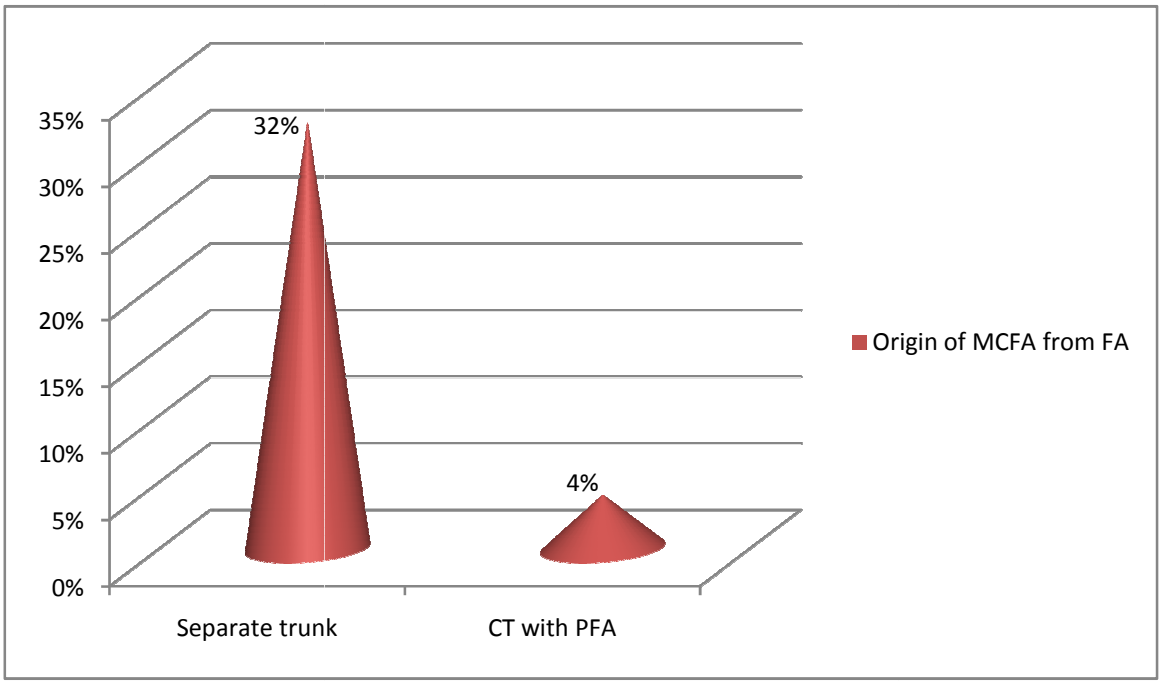


Fig.28(b) Femoral artery entering the adductor hiatus to become the popliteal artery.

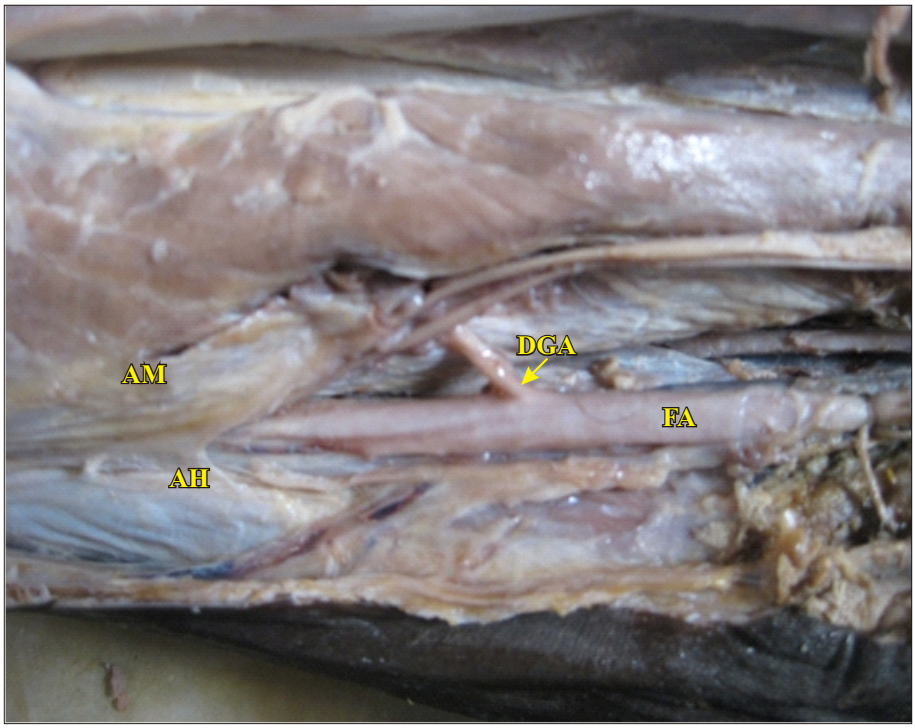


Fig.29 Normal adult angiogram

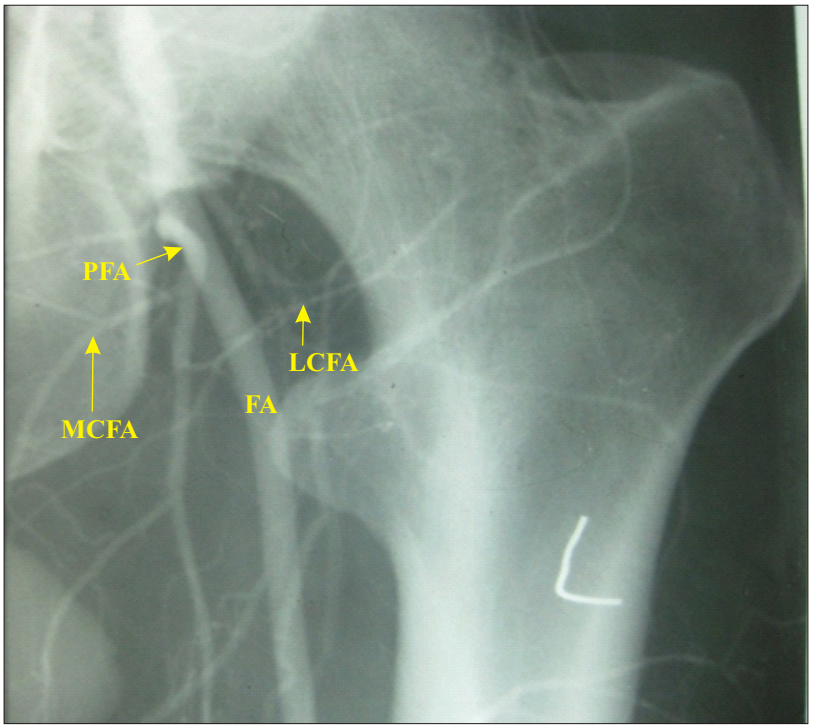


Fig.30 Descending genicular artery arising from the femoral artery

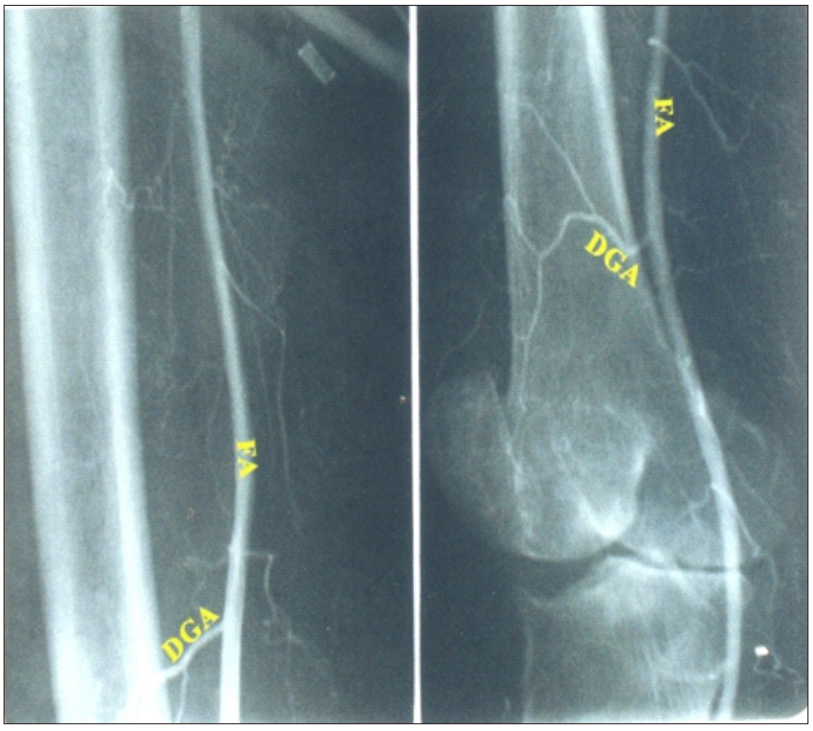


Fig.31 Profunda femoris artery arising from the lateral aspect of the femoral artery.

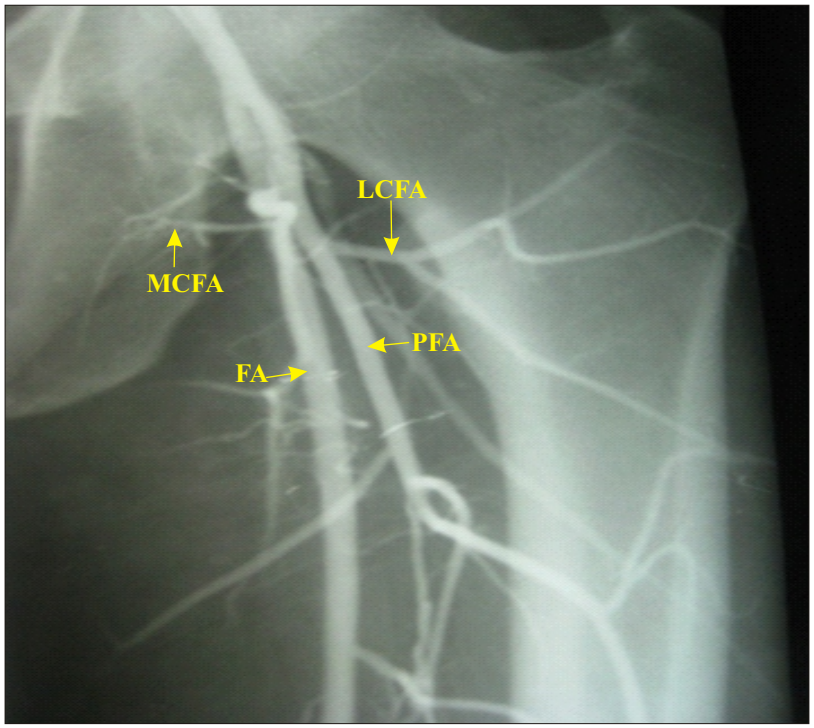
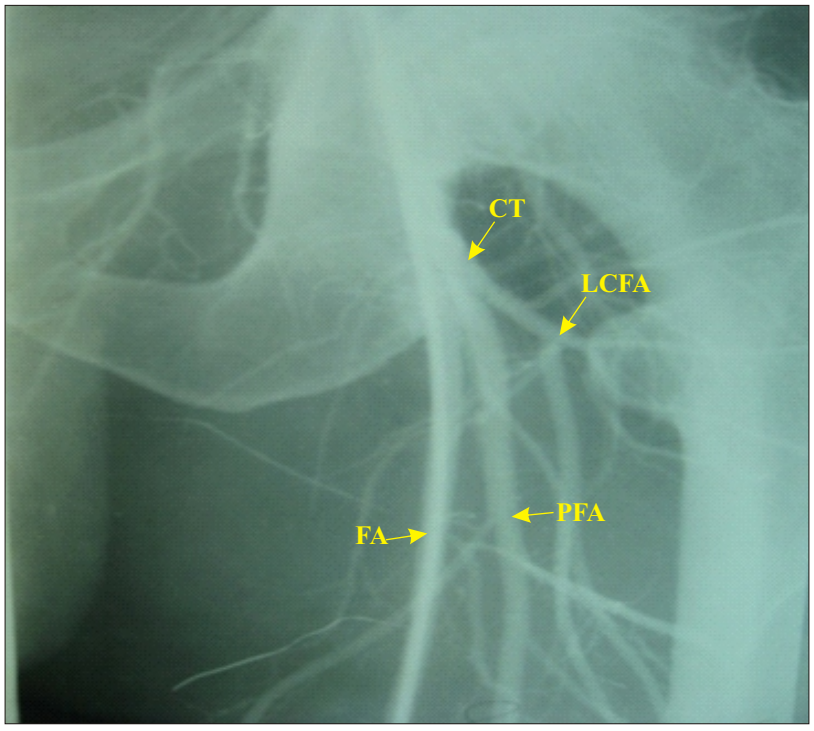


Fig.32 Lateral circumflex femoral artery arising as a common stem with profunda femoris artery



ORIGIN OF DESCENDING GENICULAR ARTERY

In all the 50 specimens studied, the DGA arose from the FA in the lower part of the adductor canal, just above the osseo aponeurotic opening in the adductor magnus(Fig.28a and 28b).

RADIOLOGICAL STUDY:

25 adult femoral angiograms:

Out of 25 adult femoral angiograms obtained from the archives of Barnard Institute of Radiology, Madras Medical College, normal branching pattern of FA was noticed in 21cases(84%). The PFA arose from the posterolateral side of FA (Fig.29), the DGA arose from the FA in the distal thigh (Fig.30).

In 1 case (4%), the PFA was seen to arise from the lateral aspect of FA.(Fig.31).

In 1 case (4%), there was CT origin of LCFA and PFA(Fig.32), and in 1 case (4%), there was common stem origin of MCFA and PFA, in which the LCFA arose directly from the FA(Fig.33).

Superficial femoral artery obstruction was identified in 1 case(4%), in which the FA distal to the origin of PFA could not be visualized(Fig.34) and extensive collaterals subsequent to the SFA obstruction were observed(Fig.35).

Fig.33 Medial circumflex femoral artery arising as a common stem with profunda femoris artery.

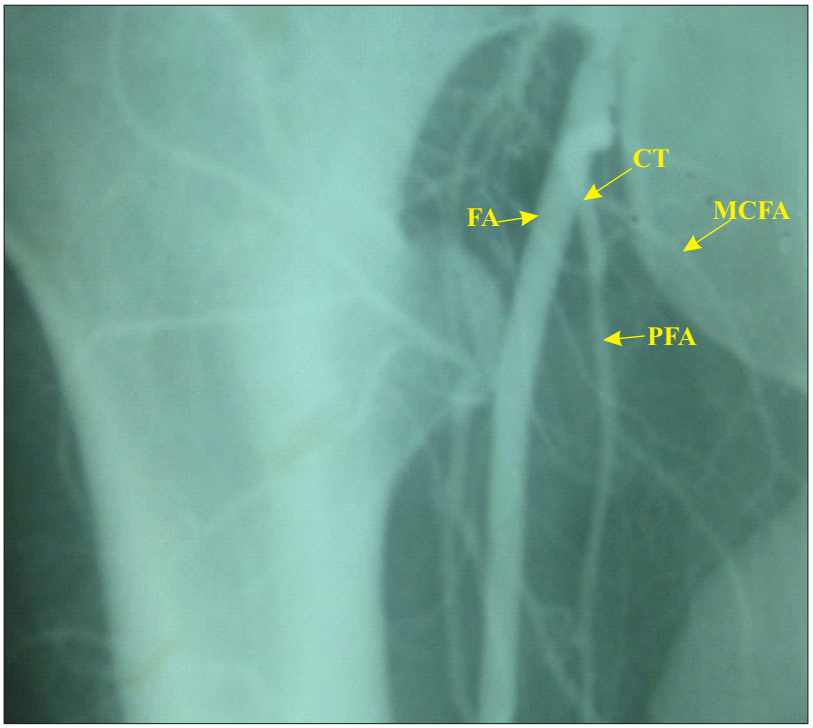


Fig.34 Superficial femoral artery obstruction

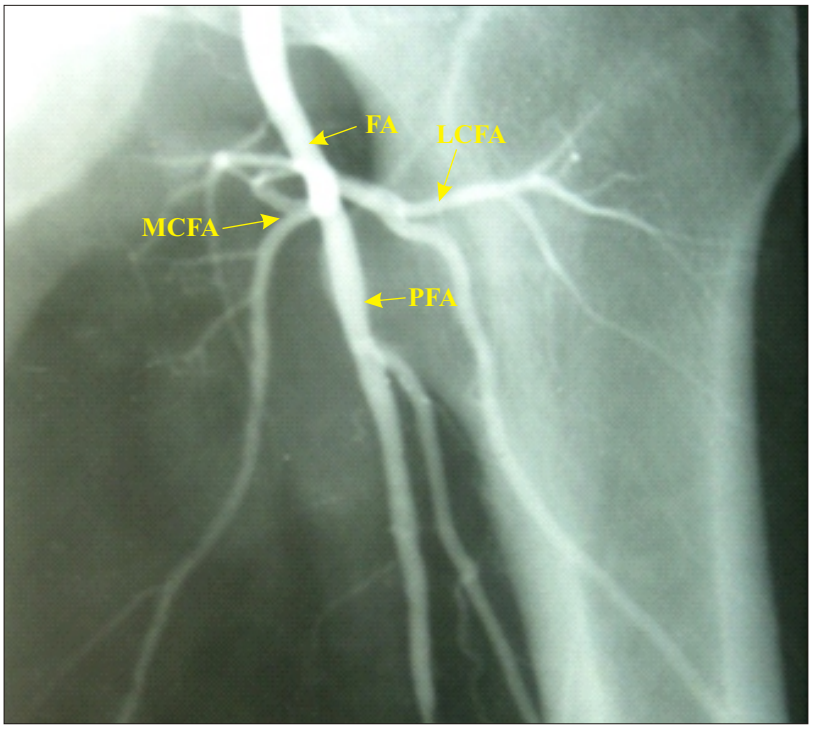


Fig.35 Extensive collaterals in superficial femoral artery obstruction

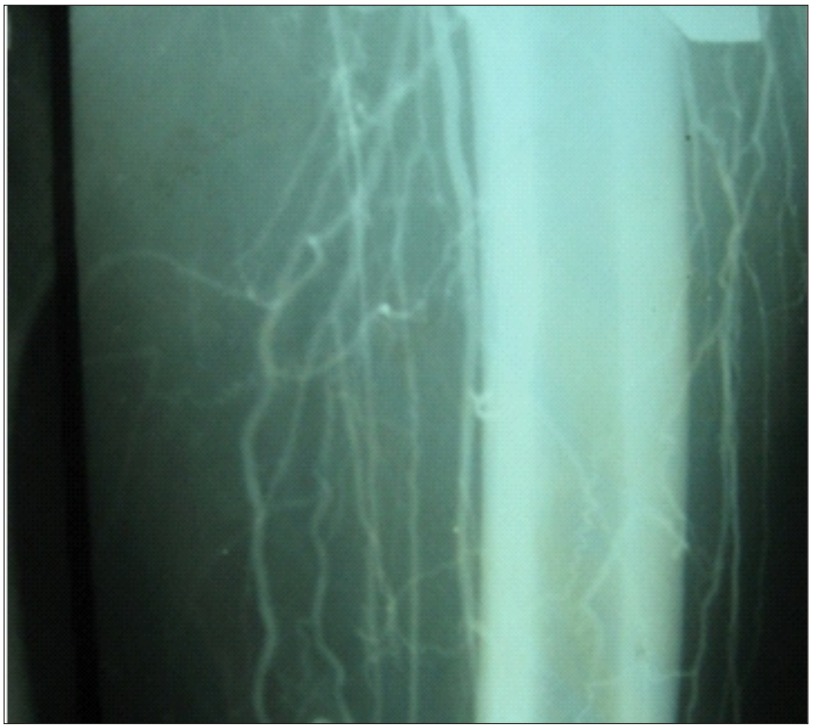


Fig.36 Normal CT angiogram of the femoral artery

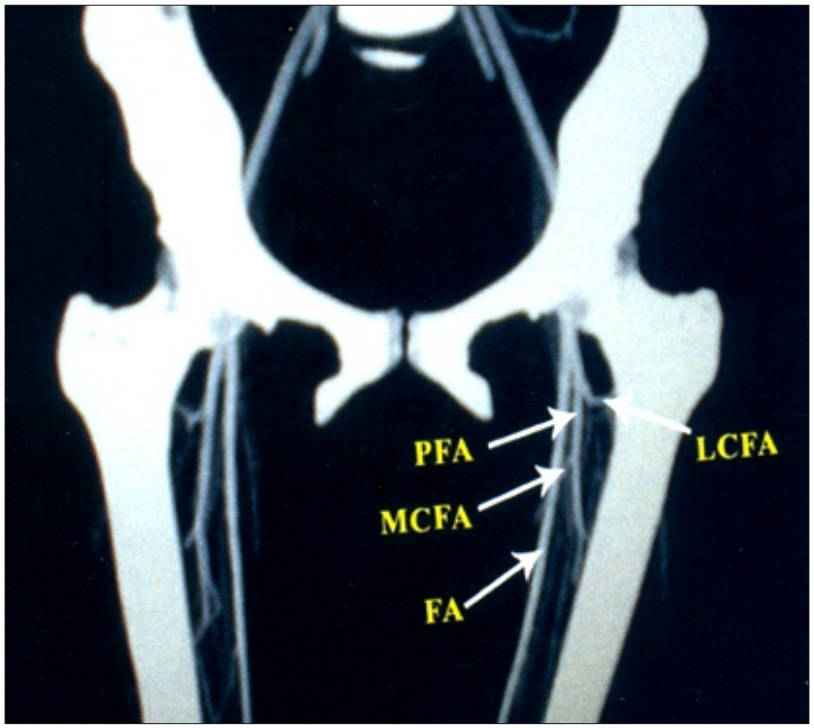
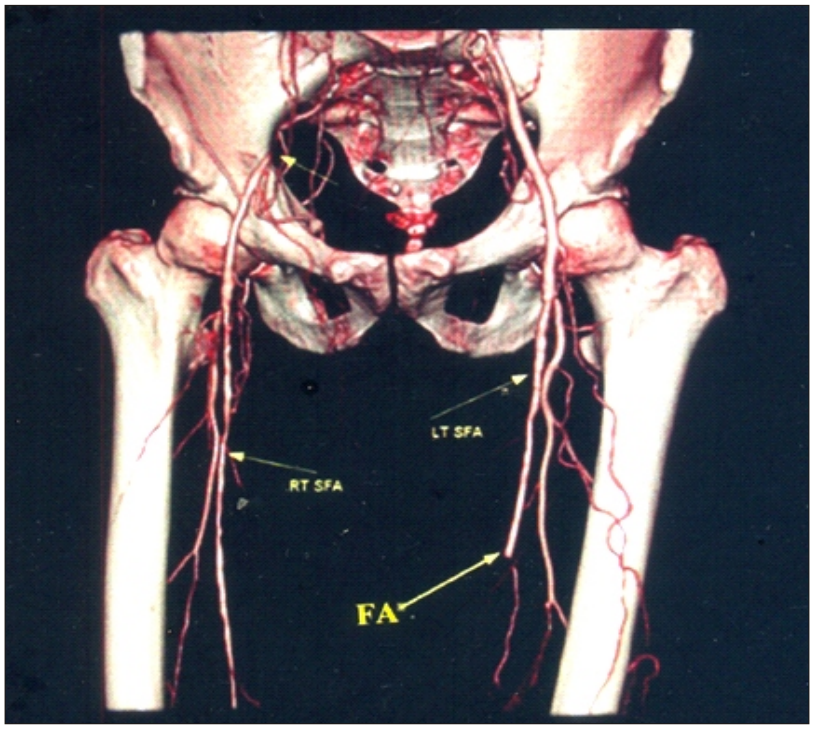


Fig.37 CT angiogram showing superficial femoral artery obstruction



10 CT(Computerised tomographic) angiograms:

Out of 10 CT angiograms reviewed, normal branching pattern was observed in 9 cases (Fig.36).Superficial femoral artery obstruction was found in 1 case(Fig.37).

Discussion

DISCUSSION

ORIGIN OF FEMORAL ARTERY IN RELATION TO THE MID INGUINAL POINT

George A Piersol [23] (1930), Chummy.S.Sinnatamby [8] (2011), J D Boyd et al [5] (1956), Richard.S.Snell [55] (2012), Barry J Anson et al [2] (1971), Keith.L.Moore [29] (2010), stated in their studies that the FA enters the thigh, midway between ASIS and the PS.

Sir John Bruce et al [61] (1964), **G.J.Romanes [21] (1972)** quoted that the femoral artery begins behind the IL.

Jeremy A Hunt et al [28] (1996) observed that the MIP can be an appropriate guide to locate the FA as it lies within 1.5cm on either side of the MIP.

Dr.P D Scott et al [14] (2005) found that the surface markings of the deep inguinal ring and the FA was closer to the MIP than to the midpoint of the inguinal ligament**.**

In the **present study,** the origin of FA was at the MIP in 44 cases(88%), which coincided with the findings of the above studies.In 6 cases (12%) the FA arose lateral to the MIP.

The relation of the FA to the MIP is variable. Clinicians catheterize the FA for various diagnostic and interventional procedures. While doing so, they should be aware, that although in majority of instances, the origin of FA coincides with the MIP, in a few occasions it may lie lateral or medial to the MIP. The above knowledge will be helpful to the clinicians when at rare occasions, they might fail to get at the FA coinciding with the MIP.

RELATION OF FEMORAL ARTERY TO THE FEMORAL VEIN IN THE FEMORAL TRIANGLE

G.J.Romanes [21] (1972) , Barry J Anson et al [2] (1971) Keith.L.Moore [29] (2010), reported that the femoral vein lies medial to the femoral artery in the upper part of the femoral triangle.

Baum PA et al [3] (1989) reported that there was a partial overlap of the FA on the femoral vein in 73%, and the FV maintained a medial relationship to the FA in 27%.

D.Hughes et al [26] (2000) stated that there was no overlap of the FV on the FA at the level of IL in 72% of patients .

Faith Kantarci M B et al [18] (2003) observed duplication of superficial femoral artery in which the FV was lying posterior to the duplicated superficial femoral artery.

Fred H Warkertine et al [19] (2008) reported that in 8% the FV completely overlapped the FA, in 4% it partially overlapped the FA and in 88% the FV was medial to the FA in the femoral triangle.

Punita Sharma et al [51] (2011) found that FV was posterolateral to the FA as it entered the adductor canal.

In the **present study,** the FV was medial to the FA below the inguinal ligament, and was posterior to the femoral artery at the apex of the femoral triangle in all the 50 specimens. Overlap of the FV and the FA below the IL, as reported in some studies mentioned above, was not observed in the present study.

In an infant dissection done on a three month old infant, the FA was seen traversing the femoral triangle, FV was medial to the FA, and the GSV was seen draining in to the FV.

The relationship of the FA and FV is clinically significant, as a femoral vein puncture might injure the FA, thus creating a arteriovenous fistula.Hence

a knowledge about the normal position of the FA and the FV and variations present if any becomes essential.

Table-14 Relationship of FA and FV

Relationship of FV to FA	D Hughes et al (2000)	Fred H Warkertine et al (2008)	Present study
No overlap-FV medial to FA.	72%	88%	100%
FA overlapped by FV	28%	12%	-

SITE OF ORIGIN OF SUPERFICIAL CIRCUMFLEX ILIAC ARTERY

Taylor and Daniel [68] (1975) reported that in 25% of cases SCIA was absent, in 45% it arose as a separate trunk from FA, in 15% as a common stem with SEA, and in 15% as a common stem with SEPA.

Robert J Allen et al [56] (2002) in their study of 100 cadavers, reported SCIA and SEA arose as a common trunk in 79%.

Mangala M Pai et al [37] (2006) said that a branch arose from the FA distal to the PFA and divided in to three branches SEA, SEPA and DEPA. In this case, the SCIA was absent.

Dr.Manjappa T et al [12] (2012) said that the SCIA arises from FA as a separate branch in 52.5%, from FA by common stem with SEA in 40%, from FA by a common trunk with SEPA and SEA in 2.5%, from PFA in 5%.

PMergu et al [40] (2014) in a case report said that the SCIA and SEA arose by a CT from the anterolateral side of the PFA.

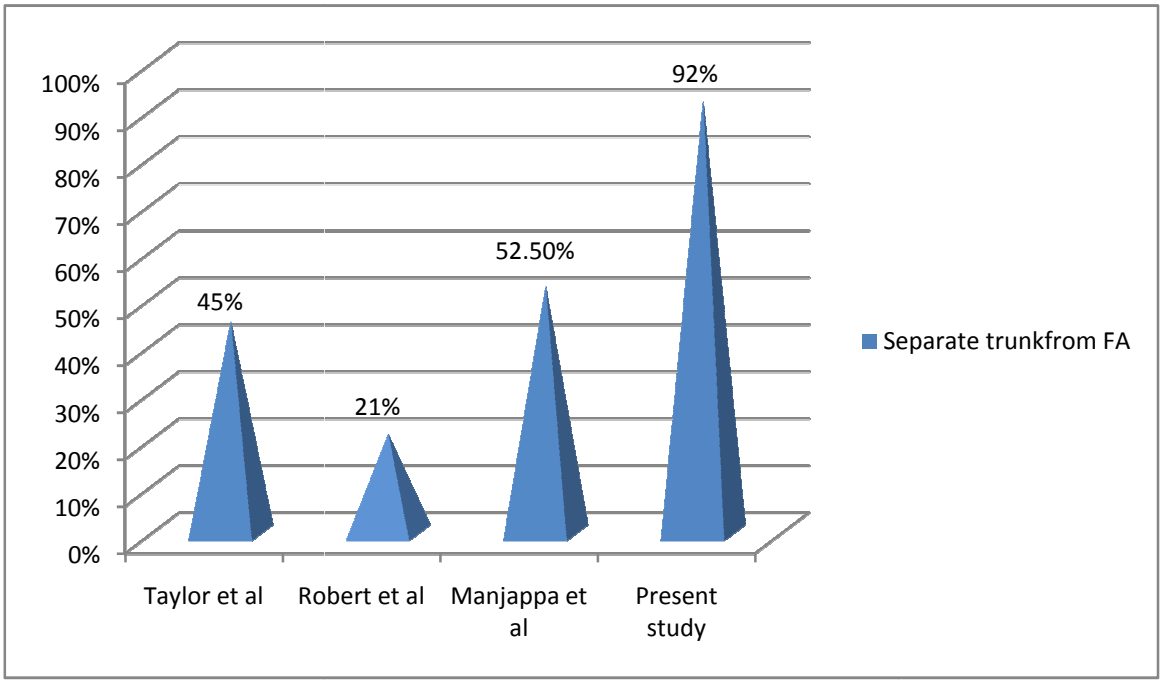
In the present study, SCIA was found to be absent in 4 cases (8%), arose as a separate trunk from FA in 36cases (92%).Common stem origin of SCIA with SEA as noted in other studies,was not observed in the present study.The SCIA was found to be absent in 8% of cases, while in study by Taylor and Daniel it was absent in 25%.

Groin flaps are mainly based on SCIA and SEA artery systems. SCIA flaps are evolved forms of groin flaps, where deep fascia is preserved, thus overcoming the disadvantage of other groin flaps. SCIA flaps can be used for reconstruction of small to moderate size defects in the lower limb. Bilateral SCIA flaps has been used for penile reconstructive procedures with the advantage of a minimal donor site morbidity and a concealed donor scar.

Table-15 Site of origin of SCIA

Site of origin of SCIA	Taylor and Daniel (1975)	Robert J allen et al(2002)	Dr.Manjappa T et al(2006)	Present study
Absent SCIA	25%	-	-	8%
Separate trunk from FA	45%	21%	52.5%	92%
Common stem with SEA	15%	79%	40%	-
Common stem with other arteries	15%		7.5%	-

Chart-12 Origin of SCIA as a separate trunk from FA



SITE OF ORIGIN OF THE SUPERFICIAL EPIGASTRIC ARTERY

Taylor and Daniel [68] (1975) observed that SEA arose as a common stem with SCIA in 15% ,and in 70% of cases as a separate trunk from FA, in 15% the SEA arose as a common stem with SEPA.

Reardon et al [53] (2004) in their dissection of 44 lower limbs, reported that in 32 cases the SEA arose from the FA as a separate trunk, and in 8 cases it arose as a common trunk with SCIA, SEPA and deep circumflex iliac artery. In 4 cases the SEA was absent.

Mahdi Fathi et al [34] (2006) reported that the SEA arose from the femoral artery as an separate trunk in 57.9%, as a common stem with the SCIA in 18.4% of cases, as CT with SEPA in 5.3% of cases, as CT with superficial femoral artery in 13.2%, and absent in 5.2%.

Manjappa T et al [12] (2012) observed , that the SEA arose from femoral artery in 47.5%, from FA by a CT with SCIA in 35%, from FA by CT with SEPA in 10%, from FA by common trunk with other arteries in 7.5%.

In the present study,the SEA arose as a separate trunk from FA in 44 specimens (88%), common stem with SEPA in 6 specimens(12%).The commonest mode of origin was a separate trunk from the FA, similar to Reardon et al study 70.1% and Taylor and Daniel study 70%. Common stem

origin with SEPA was also observed in the present study(12%),similar to Manjappa et al 10% and Taylor and Daniel study15%.

SEA flaps are used as a pedicled flap for reconstruction of upper and lower extremities, or can be used as a fasciocutaneous flap, when large amount of skin coverage is required for hemifacial atrophy or head and neck reconstruction. SEA flaps have recently been used in breast reconstructive procedures. SEA flaps utilizes the peculiar characteristics of the lower abdominal tissue, and maintains the strength and integrity of abdominal wall musculature and fascial layers.

Table-16 Site of origin of SEA

Origin of SEA from FA	Taylor and Daniel(1975)	Reardon et al (2004)	Mahdi Fathi et al(2006)	Dr,Manjappa T et al(2012)	Present study
Absent SEA	-	9.9%	5.2%	-	-
As a separate trunk	70%	70.1%	57.9%	47.5%	88%
Common stem with SEPA	15%	-	5.3%	10%	12%
Common trunk with other arteries	15%	20%	31.6%	42.5%	-

Chart-13 Origin of SEA as a separate trunk from FA

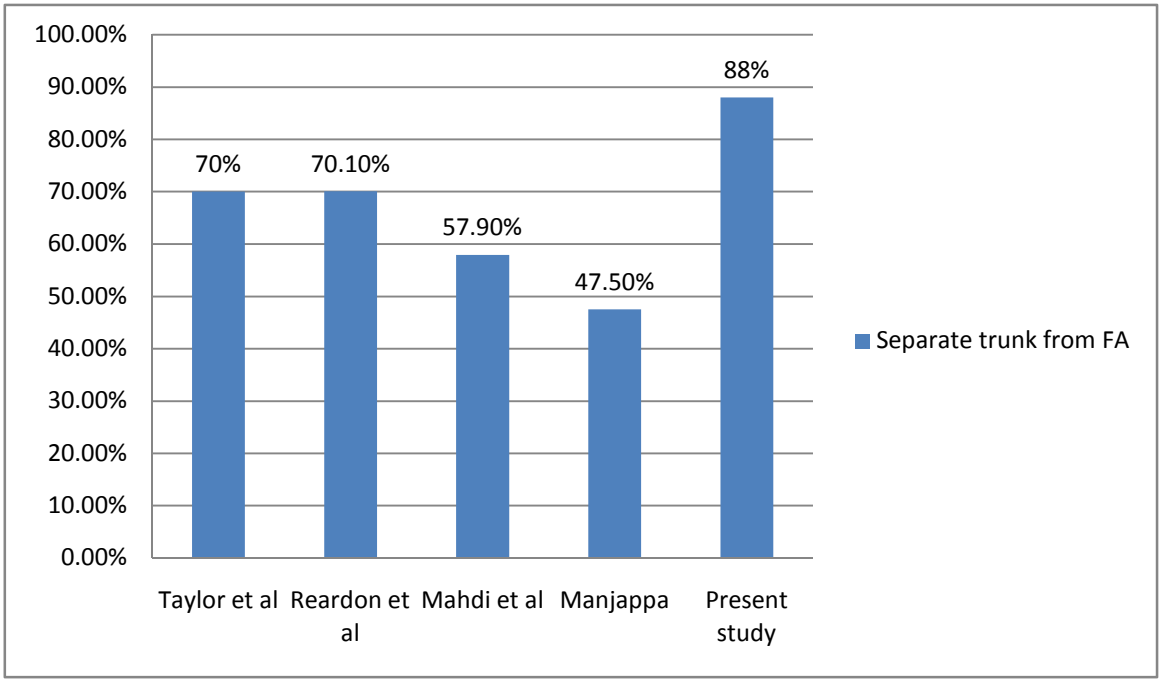
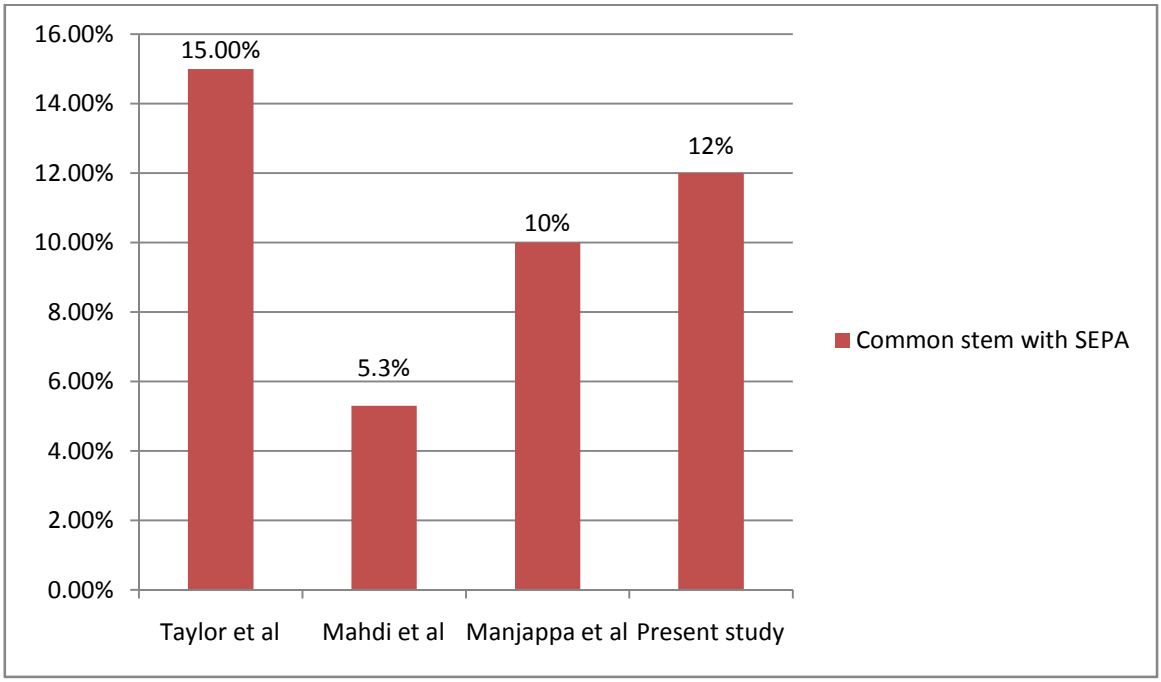


Chart-14 Origin of SEA as a common stem with SEPA



SITE OF ORIGIN OF SUPERFICIAL EXTERNAL PUDENDAL ARTERY

George A Piersol [23] (1930) stated that the SEPA arose from the medial surface of the FA and courses medially towards the external genitalia.

Castro M et al [6] (1998) found that the SEPA arose as a single vessel in 55%, duplicated in 30%, and by a common trunk with SEA in 15%.

Ercan Tanyeli et al [17] (2006) in a case report stated that the SEPA and inferior epigastric artery arose from the PFA.

Osvaldir Lanzoni La Falce et al [32] (2006) observed that the SEPA arose from the FA in 98% of cases, and from the PFA in 2%.The SEPA was duplicated in 46%, and it arose as CT in 24%, and as a single artery in 30%.

Manal.E.EL-Sawaf [36] (2010) reported a case of unusual origin of SEPA, where the SEPA and the inferior epigastric artery originated by a CT from the medial side of the EIA.

Dr. Manjappa T et al [12](2012) stated that the SEPA arises as a separate branch from FA in 57.5%,from FA by a common trunk with DEPA in 25%, by CT with SEA in 10%,by a CT with SEA and SCIA in 2.5%, from PFA in 5%.

In the present study, the SEPA arose as a separate trunk from FA in 40cases(80%), common stem with SEA in 6 cases (12%), and duplication of SEPA in 4 cases(8%). SEPA arising as a separate artery from FA was the commonest mode of origin in the present study, similar to other studies in the literature. Duplication of SEPA was also observed in the present study in 8%, while in La Falce et al study duplication was 42%, and in Castro et al study it was 30%.

SEPA flaps are used in the repair of skin defects of the penile shaft after placement of a prosthesis, in vulvar reconstruction, and in reconstruction of hand and skin injuries. Arterial anatomy of the SEPA flap is important to create a successful flap.

Table-17 Site of origin of SEPA

Origin of SEPA	Castro M et al (1998)	La Falce et al (2006)	Dr.Manjappa T et al (2012)	Present study
Separate trunk from FA	55%	30%	57.5%	80%
Common stem with SEA	15%	-	10%	12%
Duplication of SEPA	30%	46%	-	8%
CT with other arteries	-	24%	32.5%	-

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Chart-15 Origin of SEPA as a separate trunk from FA

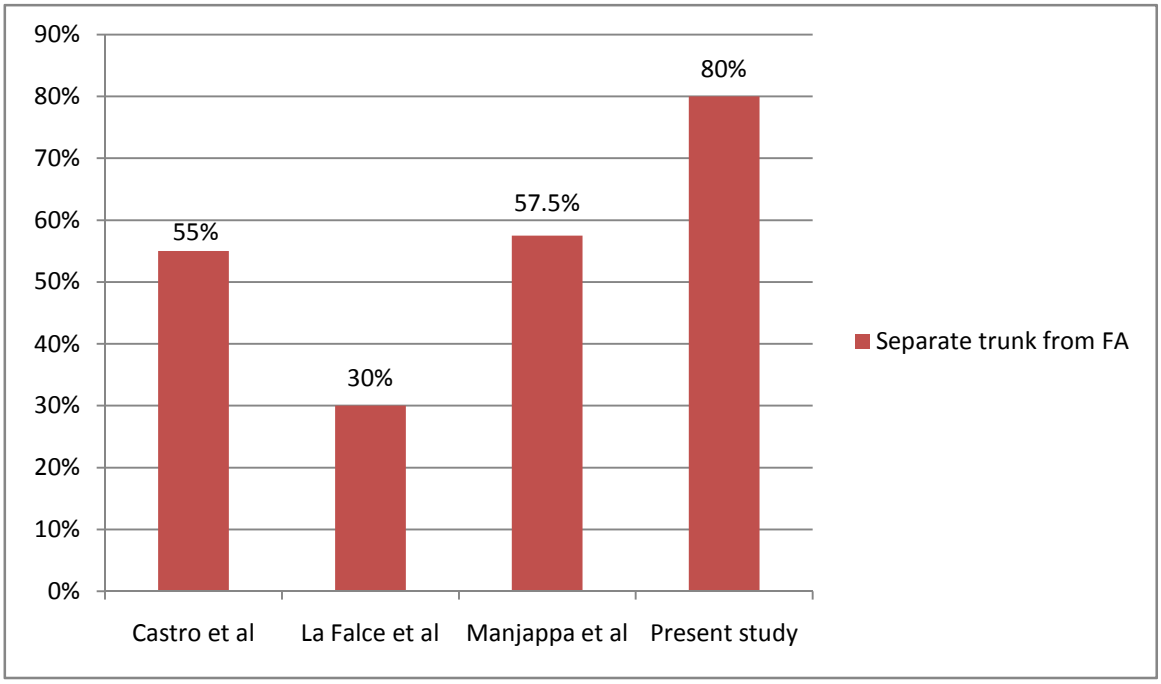


Chart-16 Origin of SEPA as a common stem with SEA

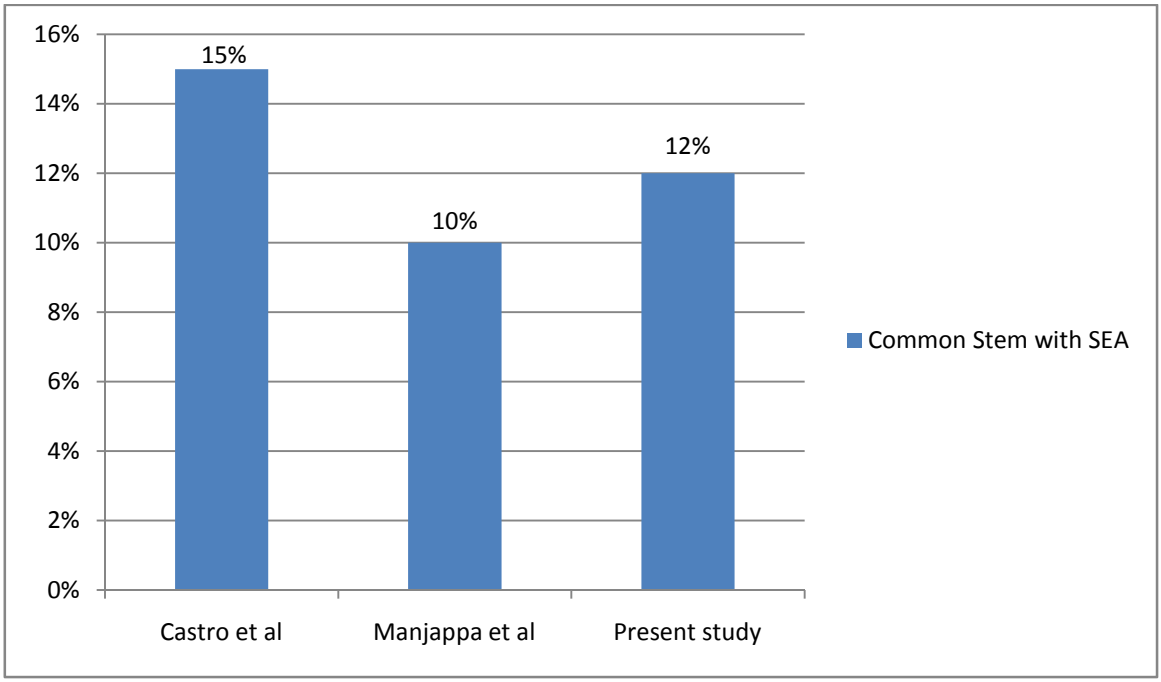
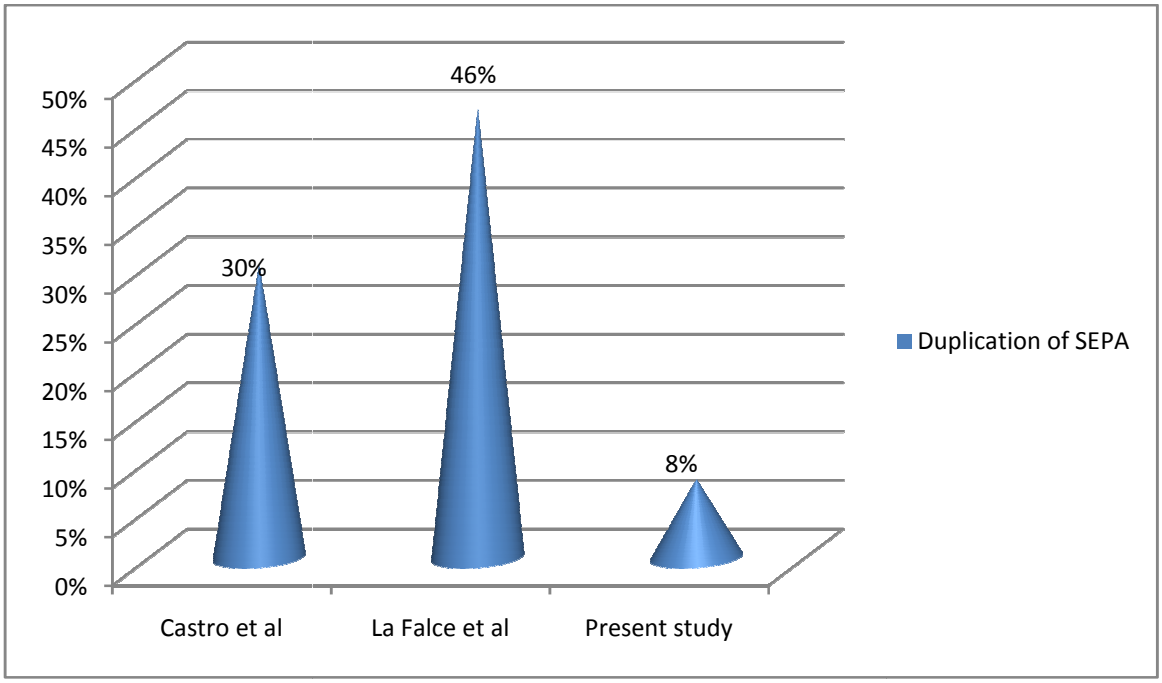


Chart-17 Duplication of SEPA



RELATION OF THE SUPERFICIAL EXTERNAL PUDENDAL ARTERY TO THE ARCH OF GREAT SAPHENOUS VEIN AT THE SAPHENOFEMORAL JUNCTION

M.Donnelly.S.Tierney et al [11] (2005) said that the SEPA could not be seen at the SFJ in 73.1%, was anterior to the GSV in 16.8%, and above the SFJ in 10.1%.

Ass Ndaiye et al [1] (2006) found that the SEPA was posterior to the arch of GSV in 56% of cases and anterior in 44% of cases.

Preethi [50] (2008) stated that the SEPA was not visualized at the SFJ in 74%, the SEPA passed posterior to the GSV in 16%, and anterior to it in 10%.

Hemmati H et al [25] (2012) stated that SEPA crossed anterior to the GSV in 39.5% and crossed posterior to the GSV in 60.5%.

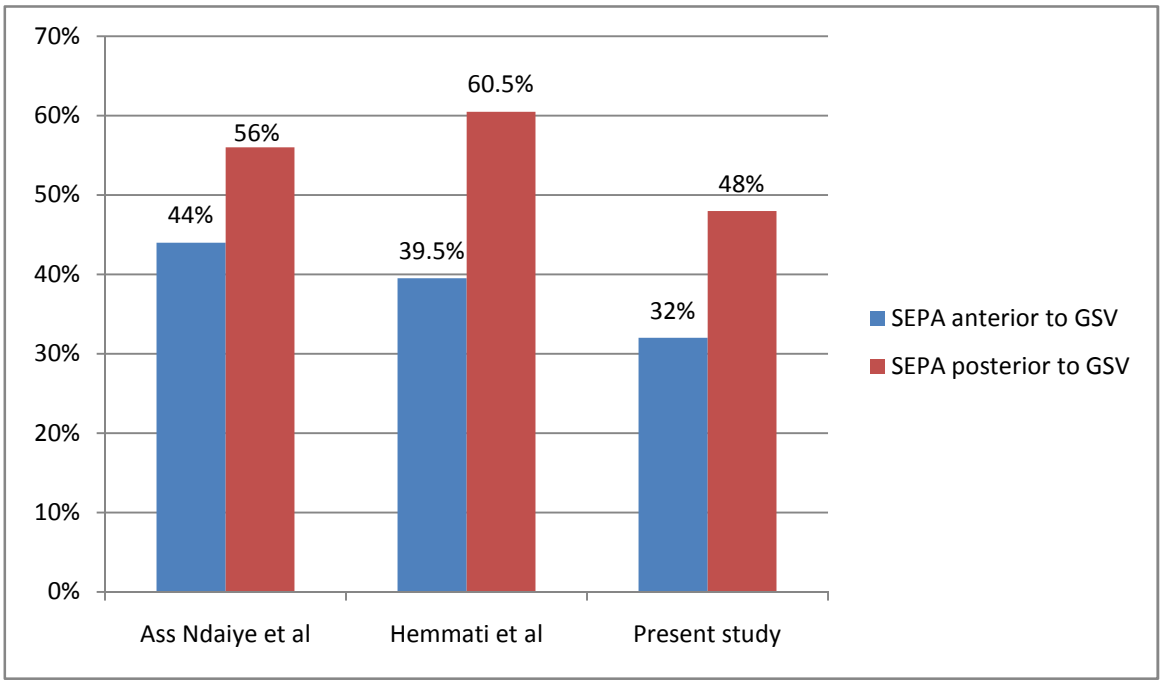
In the present study,the SEPA was not seen at the SFJ in 10 cases (20%), was anterior to the GSV in 16 cases(32%), and in 24 cases (48%)the SEPA was posterior to the GSV. In 20% of cases, the SEPA was found to be above the SFJ, below the IL. In study by Preethi, there was a higher incidence of SEPA not being visualized at the SFJ(74%), but in the present study only in 20%, the SEPA was not seen at the SFJ.The percentage of SEPA going anterior or posterior to the GSV was comparable to other studies in the literature.

The anatomic variability of the SFJ is important for treatment of varicose veins. In patients with varicose veins undergoing surgery, it is mandatory to demonstrate the various tributaries of the FV at the SFJ**,** and their relation to the SEPA as an incomplete surgery would result in recurrence. The clinical significance of the relation of the SEPA to the GSV is important in ensuring that the SFJ is managed safely which results in effective surgical exploration and thereby success of the varicose vein surgery.

Table-18 Relationship of SEPA to the GSV at SFJ

Studies	SEPA not visualized	SEPA anterior to GSV	SEPA posterior to GSV	Above SFJ
Donnelly et al (2005)	73.1%	16.8%	-	10.1%
Ass Ndaiye et al(2006)	-	44%	56%	
Hemmati et al (2012)	-	39.5%	60.5%	
Present study	20%	32%	48%	

Chart-18 Relationship of SEPA to the GSV at SFJ



SITE OF ORIGIN OF THE DEEP EXTERNAL PUDENDAL ARTERY

George A Piersol [23] (1907), Russel T Woodburne [57] (1957), Barry J Anson et al [2] (1971),stated that the DEPA arises from the medial side of the FA.

Sir John Bruce et al [61] (1964) reported that the DEPA arises from the FA near its origin.

Romanes G J [21] (1972), Richard S Snell [55] (2012), reported that the DEPA originates from the FA and runs medially to supply the skin of the external genitalia.

Nam YS et al [42] (2005) found the SEPA was located above the saphenous opening, and the origin of DEPA located below the saphenous opening.

Mamatha H et al [35] (2012) reported a low origin of the DEPA, about 5 cm from the MIP.

Suthar K et al [64] (2013) stated that the DEPA arises from the medial side of the FA in 96% of cases, and in 4% it arises from the antero medial side.

In the present study, in all the 50 specimens (100%) the DEPA originated from the medial side of the FA similar to other studies. In 2 cases(4%), the DEPA arose from the FA distal to the origin of PFA.

The DEPA may be injuired while doing adductor tenotomy during total hip replacement especially in patients with fragile arterial walls and life threatening complications can occur. Hence the knowledge of the origin of DEPA and its course becomes significant to minimize complications.

SITE OF ORIGIN OF THE PROFUNDA FEMORIS ARTERY

George A Piersol [23] (1907), Chummy S Sinnathamby [8] (2011), Keith L Moore [29](2010), stated that the PFA arises from the lateral side of the FA.

Parson's Schaffer [27] (1952) stated that the PFA arises from the posterolateral side of the FA.

Dixit D P et al [10] (2001) stated that the PFA originated from the postero lateral aspect of the FA in 35.41%, from the posterior aspect in 31.25%, the remaining from the lateral aspect of the FA.

Ercan Tanyeli et al [17] (2006) in a case report found that the PFA arose from the anterior aspect of the FA.

R Chitra [52] (2008) in a case report observed that the PFA originated from the medial side of the FA to pass in front of the femoral vein.

M B Samarawickrama et al [39] (2009) observed that the PFA originated from posterior aspect of FA in 12 cases, from posterolateral side in 8 cases, from lateral aspect in 6 cases.

Prakash et al [49] (2010) stated that the PFA arose from the postero lateral aspect of the FA in 50%, from the posterior aspect in 46.9%, from the medial side of the FA in 3.1%.

Daksha Dixit et al [9] (2011) found that the PFA arose from the posterolateral aspect of the FA in 42.1% ,posterior aspect in 28.5%, lateral side in 18.8% and from the medial side of the FA in 10.6%.

Kulkarni R N et al [31] (2012) in a case report, said that the PFA on both sides arose from the medial side of the FA.

Siriporn Thitilertdecha et al [62] (2012) observed that the PFA separated from the posterior aspect of FA in 44.64%, from the posterolateral aspect in 30.36%, from lateral aspect in 21.43%, from medial aspect of FA in 3.57%.

Suthar K et al [64] (2013) stated that the PFA originated from the posterior aspect of the femoral artery in 8%, from posterolateral aspect in 52%, and from the lateral aspect of the femoral artery in 40%.

In the present study, the PFA arose from the posterolateral side of the FA in 32 cases(64%), from the posterior side of the FA in 12 cases (24%),and from the lateral side of the FA in 6 cases(12%).This observation was similar to Suthar et al,Siriporn et al,Prakash et al,and Dixit DP et al studies.The origin of PFA from the medial side of the FA, reported in some studies mentioned above was not observed in the present study.

Knowledge about the site of origin of the PFA is helpful while doing a femoral puncture, to avoid iatrogenic arteriovenous fistula which easily occurs when the PFA arises from the medial side of the FA and passes in front of the FV. Anatomical knowledge of variations present in the site of origin and the branching pattern of the PFA is significant to minimize complications in various surgical procedures like Hip joint replacement, repair of femoral hernia and vascular reconstructive surgeries of the femoral region.

Table-19 Site of origin of PFA from FA

Site of origin of PFA from FA	Dixit et al (2001)	Prakash et al (2010)	Siriporn Thitilertdecha et al (2012)	Suthar K et al (2013)	Present study
Posterolateral	35.41%	50%	30.36%	52%	64%
Posterior	31.25%	46.9%	44.64%	8%	24%
Lateral	33.34%	-	21.43%	40%	12%
Medial	-	3.1%	3.57%	-	-

Chart-19 Origin of PFA from the posterolateral aspect of the FA

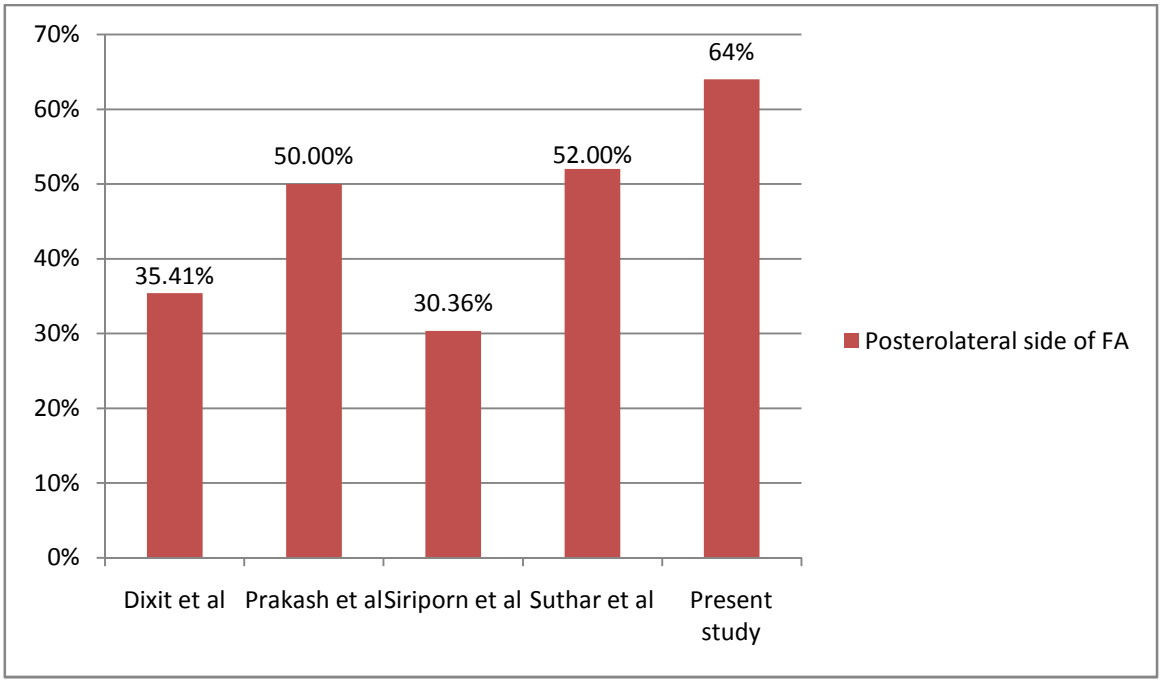
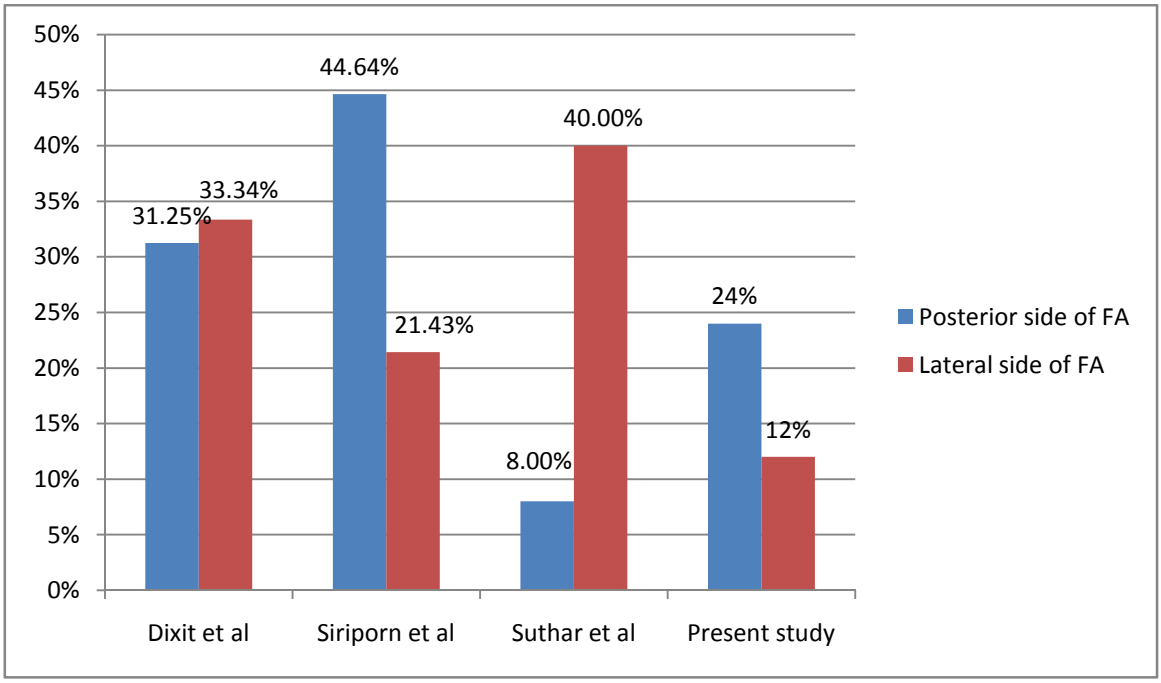


Chart-20 Origin of PFA from posterior and lateral aspect of FA



DISTANCE OF ORIGIN OF THE PROFUNDA FEMORIS ARTERY FROM THE MID INGUINAL POINT

Russel T Woodburne [57] **(1957)** said that the PFA arises 5 cm below the IL.

W.Henry Hollinshed [75] **(1966)** stated that the PFA arises from the FA, approximately 4-5cm below the IL.

Siddharth P et al [45] **(1985)** stated that the median distance of origin of PFA measured from the MIP was 4.4cm.

Dixit D P et al [10] (2001) described the distance of separation of the PFA from the MIP to be 4.75cm.

Mangala M Pai et al [37] (2006) observed that the PFA arose from the FA about 1.2 cm below the IL.

Dr.Marina Baptist et al [13] (2007) stated that the average distance of origin of the PFA from the midpoint of the inguinal ligament was between 30-40mm. Only in 10% of cases, the PFA origin was between 60-70mm.

Vuksanovic-Bozanc A et al [74] (2007) stated that the PFA originated at a distance of 3.75 cm from the MIP.

M B Samarawickrama et al [39] (2009) observed that the PFA origin was at a distance of 50mm from the MIP.

Prakash et al [49] (2010) stated that the mean distance of origin of PFA from the MIP was 4.2cm.

Vishal Kumar et al [72] (2011) reported a case of high origin of PFA, originating just lower to the IL.

Mamatha H et al [35] (2012) found that the PFA originated at a distance of 3.9cm from the MIP. They also reported one case of high origin of PFA,

where the artery branched out from the FA at a distance less than 1cm from the MIP.

Richard S Snell [55] (2012) observed that the PFA arises about 4 cm below the IL.

Siriporn Thitilertdecha et al [62] (2012) observed that the mean distance of origin of the PFA from the MIP was 34.61mm.

Pooja Jain et al [48] (2013) in a case report observed that the PFA arose 2 cm distal to the MIP in the right side, and a high origin of PFA from FA at the level of MIP on the left side.

Suthar K et al [64] (2013)) reported that the PFA arose at a distance of 4.62cm from the MIP.

P Mergu et al [40] (2014) reported that the PFA arose 1 cm below the IL.

In the present study, the mean distance of origin of PFA from MIP was found to be 4.31cm. In 2 cases(4%) there was high origin of PFA which arose at a distance of 2 cm from the MIP. High origin of PFA have been reported in Mangala Pai et al, Vishal Kumar et al, Mamatha et al, Pooja Jain et al, and Mergu et al studies.

Profunda femoris artery is used in vascular reconstructive procedures of the proximal leg. The PFA is useful in arteriography, ultrasound, Doppler imaging, digital subtraction angiography and magnetic resonance imaging. Hence knowledge of variations in height origin of PFA from the FA is very significant.Percutaneous FA cannulation can cause pseudoaneurysms when the puncture site is the PFA or the FA distal to the origin of PFA.Lack of knowledge of variations in the height origin of the PFA makes haemostasis difficult to manage.

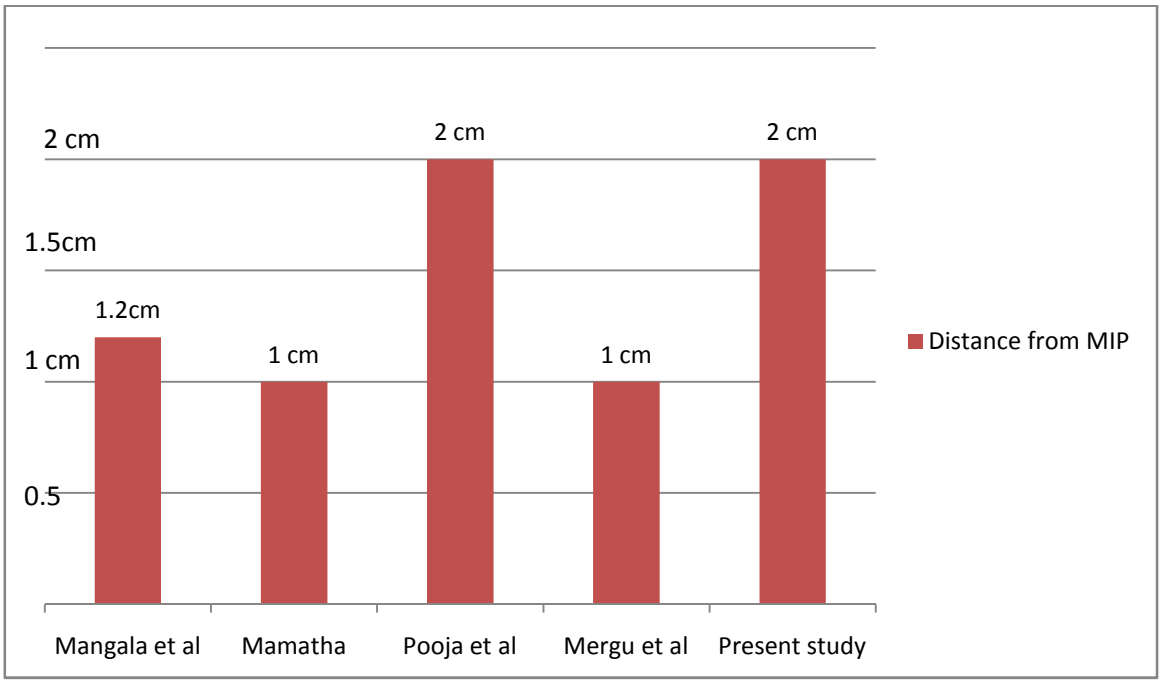
Table-20 Distance of origin of PFA from MIP

Studies	Distance of origin of PFA(cm)
Siddharth P et al (1985)	4.4
Snell RS (1992)	4
Dixit DP et al (2001)	4.75
Vuksanovic Bozanc.A.(2007)	3.75
M B Samarawickrama et al (2009)	5
Prakash et al (2010)	4.2
Mamatha H et al (2012)	3.9
Siriporn Thitilertdecha et al (2012)	3.46
Suthar K et al (2013)	4.62
Present study	4.31

Table-21 High origin of PFA from FA

Studies	Distance from MIP (cm)
Mangala Pai et al (2006)	1.2
Mamatha et al (2012)	1
Pooja Jain et al (2013)	2
Mergu et al (2014)	1
Present study	2

Chart-21 High origin of PFA from FA



SITE OF ORIGIN OF LATERAL CIRCUMFLEX FEMORAL ARTERY

Romanes G J [21] (1972), observed that the LCFA springs from the PFA near its origin.

Fukuda H et al [20] (2005) described that the LCFA was given off from the PFA in 78.6%, from the FA in 21.4%.

Choi SW et al [7] (2007) reported that the origin of LCFA was from the PFA in 86.8%, and from the FA in 13.2%.

Tansatit T et al [66] (2008) stated that the LCFA arose from the PFA in 56.67%, from the FA in 43.33%.

Uzel M et al [69] (2008) found that the LCFA originated from the PFA in 77.3%, from the FA in 22.7%. In 1.8% of cases, the ascending and descending branches of LCFA was found to arise directly from the PFA or FA. In 0.9% LCFA had a CT origin with PFA and in 0.9% the PFA,LCFA and the MCFA arose by a CT.

Chummy S Sinnatamby [8] (2011) stated that the LCFA arises from the PFA, or occasionally from the FA.

Daksha Dixit et al [9] (2011) observed that the LCFA originated from the PFA in 72.8%, and from the FA in 27.2%. LCFA and PFA arose by a CT in 17.5%. All three branches of the LCFA arose directly from the PFA in 0.8%.

Mamatha H et al [35] (2012) reported that in 2.5% of cases, the descending branch of LCFA arose directly from the PFA, in 2.5% the ascending and transverse branches of the LCFA arose as a CT originating from the PFA. In 2.5% the descending branch of the LCFA arose directly from the FA.

Sinkeet SR et al [60] (2012) found that the LCFA arose from PFA in 65.5%, from FA in 34.5%. Origin from FA included CT origin with MCFA in 14.3%, CT with PFA in 10.7% and as a separate trunk in 2.4%. There was trifurcation with PFA and MCFA in 7.1%.

Pooja Jain et al [48] (2013) reported a double LCFA on the right side in their case report of a male cadaver during routine dissection. The accessory LCFA arose from the FA beneath the MIP, and the SEA,SCIA and SEPA originated from the accessory LCFA.

Suthar K et al [64] (2013) reported that the LCFA originated from the PFA in 80% ,and from the FA in 20%.

Pavan P Havaldar et al [46] (2014) stated that the LCFA took origin from the PFA in 90%, from the FA in10%.

In the present study, the LCFA arose from the PFA in 36 cases(72%), and from FA in 14 cases(28%), similar to studies mentioned above.

Out of 36 cases, in 2 cases (4%) all the three branches of LCFA was arising directly from the PFA.

Out of 14 cases, in 4 cases (8%), the LCFA and the PFA arose as a CT from the FA.

The variable origins of the LCFA makes it vulnerable to iatrogenic injury during surgeries like Total hip replacement. Branches of LCFA are used in aortopopliteal bypass, coronary artery bypass graft(CABG), and perforators are important in anterolateral thigh flaps for reconstructive surgeries. Descending branch of the LCFA can act as a collateral in obstruction of the superficial femoral artery. Some studies have reported the use of LCFA as a option for reconstruction of large defects secondary to gunshot wounds of the face. As the LCFA has many clinical implications, the knowledge of its origin and variations in the branching pattern becomes important.

Table-22 Site of origin of LCFA

Origin of LCFA	From PFA	From FA(including common stem)
Fukuda H et al(2005)	78.6%	21.4%
Uzel M (2008)	77.3%	22.7%
Daksha Dixit (2011)	72.8%	27.2%
Sinkeet SR et al(2012)	65.5%	34.5%
Present study	72%	28%

Chart-22 Site of origin of LCFA

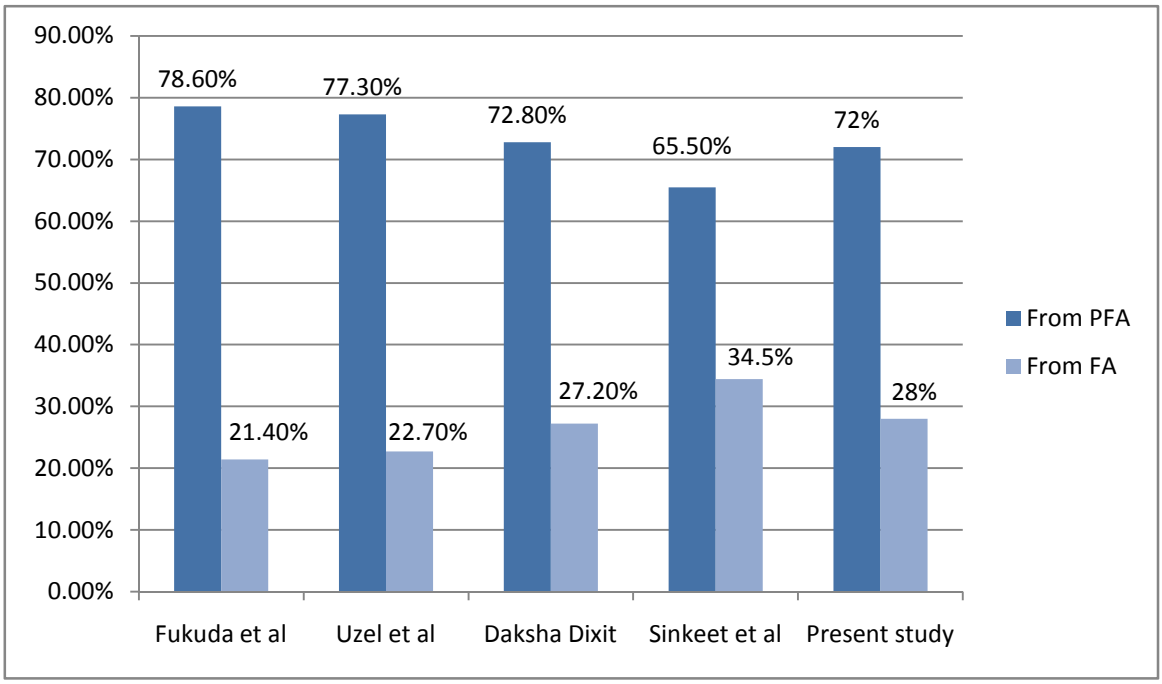


Table-23 Variations in the origin of LCFA

Variant origin	Uzel et al (2008)	Daksha Dixit et al (2011)	Mamatha et al(2012)	Sinkeet et al (2012)	Present study
Branches of LCFA directly from PFA/FA	1.8%	0.8%	7.5%		4%
CT with PFA and MCFA	0.9%	-	-	7.1%	-
CT with PFA	0.9%	17.5%	-	10.7%	8%

Chart-23 Branches of LCFA arising directly from PFA

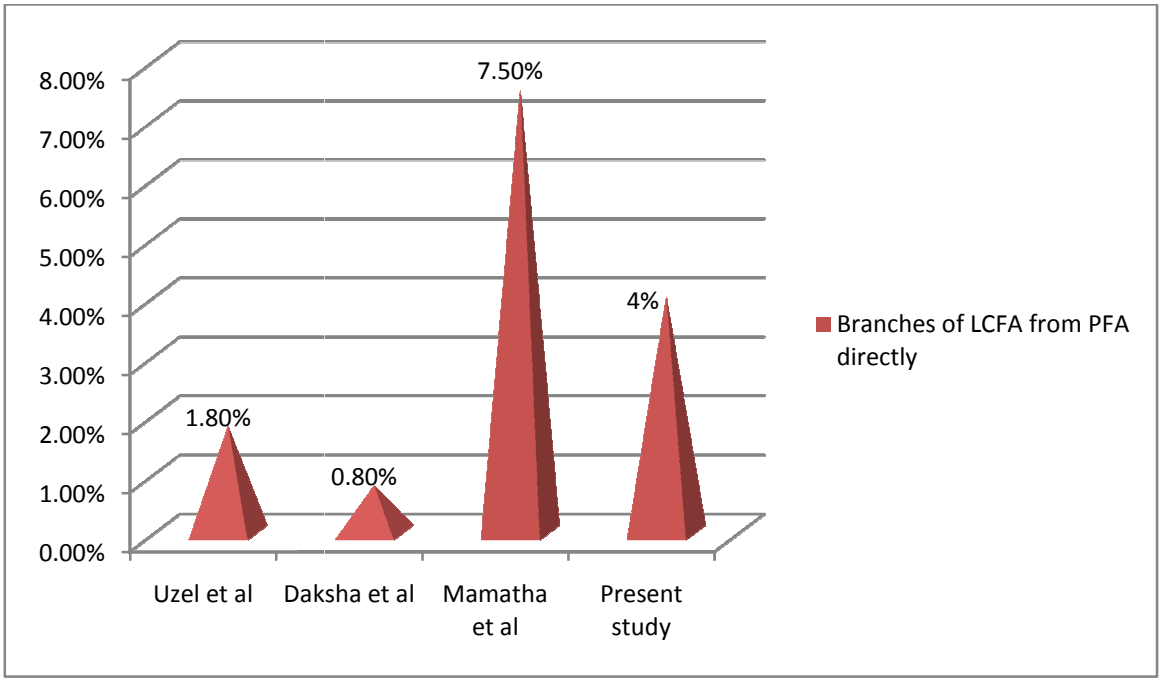
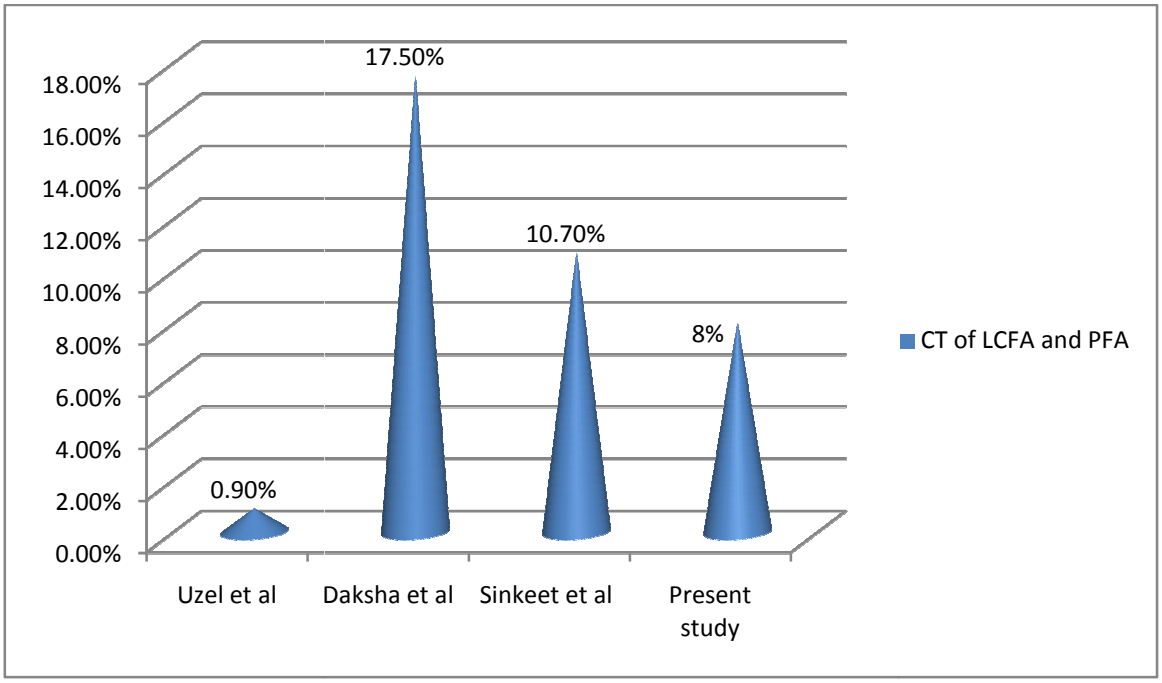


Chart-24 LCFA arising as a CT with PFA



11.SITE OF ORIGIN OF MEDIAL CIRCUMFLEX FEMORAL ARTERY

W.Henry Hollinshed [75] (1966) observed that the MCFA typically arises from the medial or posteromedial side of the PFA, but has an independent origin from the FA, more frequently than does the LCFA.

Romanes G J [21] (1972), stated that the MCFA arises from the PFA, at the same level as LCFA.

Siddharth P et al [45] (1985) said that the MCFA arose from the PFA in 63%, from the FA in 37%.

Clarke S M et al [58] (1993) observed that the origin of MCFA was from the PFA in 53% and was from the FA in 47%.

Gautier E et al [22] (2000) reported that the MCFA arose from the PFA in 83.3%,and from the FA in 16.7%.

Tanyeli E et al [67] (2006) found that the origin of MCFA was from the PFA in 79% , and from the FA in 21%. In 4% the MCFA was found to be double, with one MCFA branching out from the PFA, and the other MCFA from the FA. In 2% PFA and the MCFA had a CT origin.

M B Samarawickrama et al [39] (2009) observed that the MCFA arose from the PFA in 62%, from the FA in 38%. There was CT origin of MCFA and PFA from the FA in 8%.

Keith L Moore [29] (2010), stated that the MCFA and LCFA arises from the PFA, may arise from the FA.

Prakash et al [49] (2010) found that the MCFA originated from the PFA in 67.2%, from the FA in 32.8%.

Daksha Dixit et al [9] (2011) stated that the MCFA arose from the PFA in 56.1%, from FA in 43.9%, which included CT origin in 14%.

Mamatha H et al [35] (2012)) found that the MCFA arises from the PFA in 97.5%, and from the FA in 2.5%.The origin of MCFA from the FA was 3.2cm proximal to the PFA origin.

P Mergu et al [40] (2014) stated in a case report that the MCFA originated from the posterior aspect of the PFA,very close to PFA origin below the inguinal ligament. In this case the deep circumflex iliac artery also arose from the PFA.

In the present study, the MCFA originated from the PFA in 64% of cases, from the FA in 36% of the cases. This observation was similar to other studies in the literature noted above. In 2 cases(4%) MCFA was arising as a CT with PFA. Common trunk of MCFA with PFA have been reported in Tanyeli et al and Daksha et al studies.

The MCFA is the main artery supplying the head and neck of femur, and is usually injured during femoral neck fractures. Precise knowledge of the anatomy ofMCFA is essential when performing trocanteric and intertrocanteric osteotomies. Knowing the branching pattern of the MCFA is also helpful to avoid iatrogenic vascular necrosis of the head of the femur in reconstructive surgeries of the hip and fixation of acetabular fractures through posterior approaches. Hence surgeons operating around the hip region should be familiar with the variations of MCFA. Knowledge of the anatomy and

branching pattern of MCFA is also important during flap surgery to be performed in the upper medial femoral region.

Table-24 Site of origin of MCFA

Origin of MCFA	From PFA	From FA (including common stem)
Siddharth P et al(1985)	63%	37%
MB Samarawickrama(2009)	62%	38%
Prakash et al(2010)	67.2%	32.8%
Daksha Dixit(2011)	56.1%	43.9%
Present study	64%	36%

Chart-25 Site of origin of MCFA

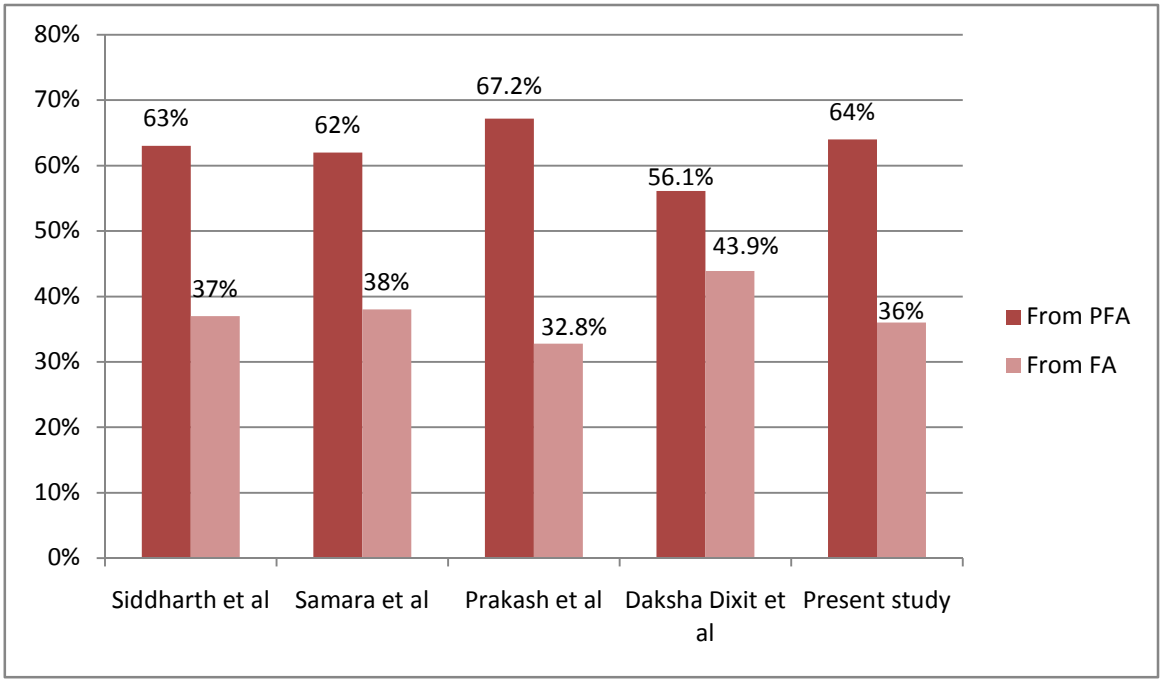
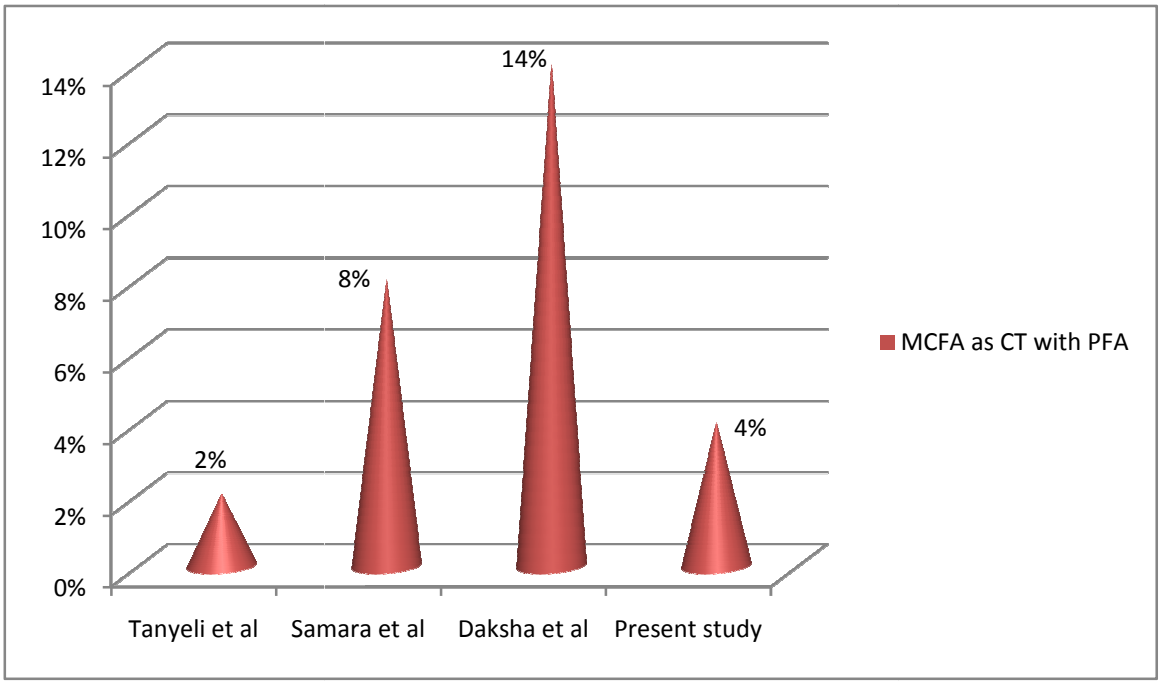


Table-25 Origin of MCFA as a CT with PFA

Studies	CT of MCFA and PFA
Tanyeli et al (2006)	2%
Samarawickrama et al (2009)	8%
Daksha et al (2011)	14%
Present study	4%

Chart-26 Origin of MCFA as a CT with PFA



ORIGIN OF DESCENDING GENICULAR ARTERY

George A Piersol [21] (1907), stated that the DGA originates from the FA, just before it passes through the adductor magnus.

Russel T Woodburne [57] (1957), quoted that the DGA is given off from the FA, just before it passes through the adductor hiatus.

W.Henry Hollinshed [75] (1966) stated that the DGA arises close to the lower end of adductor canal from the FA.

Gocmen-Mas N et al [24] (2012) in which the pedicles of the saphenous flap was dissected in 32 legs of adult cadavers, found that the DGA originated from the FA in all the cases.

Richard S Snell [55] (2012), reported that the DGA is a small branch that arises from the FA, near its termination.

Suthar K et al [64] (2013) observed that the DGA arises from the superomedial side of the FA.

In the present study, the DGA originated from the FA , just above the adductor hiatus, in all the cases (100%).

The increasing use of free vascular flaps of the DGA and its branch ,the saphenous artery makes the knowledge of the origin and course of DGA significant. DGA is the main supply to the medial distal femoral periosteum which can be used as a vascular corticoperiosteal graft. Anatomic variability of the artery could have an implication on the viability of the graft. DGA flaps have a reliable blood supply and suitable thickness for treatment of soft tissue defects of the extremities.

Conclusion

CONCLUSION

The study of femoral artery and its branching pattern has been a great interest among anatomists and surgeons,as it has wide clinical and radiological implications.The artery was studied by dissection and radiological methods. The site of origin of the femoral artery and its branches, site of origin of its main branch, the profunda femoris and its circumflex branches were studied and the following conclusions drawn:

- The origin of the femoral artery coincided with the MIP in 88% of the cases and it was lateral to the MIP in 12% of the cases.
- The FV vein was medial to the FA in the femoral triangle in all the cases (100%).
- The SCIA was absent in 8%. It arose as a separate trunk from the FA in 92%.
- The SEA originated as a separate trunk from FA in 88%, while it arose as a common stem with SEPA in 12%.
- The SEPA arose as a separate trunk from FA in 80%, common stem with SEA in 12%, and there was duplication of SEPA in 8%.

- SEPA was not visualized at the SFJ in 20%, SEPA was anterior to the GSV in 32%, was posterior to the GSV in 48%. In 20%,the SEPA arose above the saphenofemoral junction, along with other superficial branches, below the IL.

- The deep external pudendal artery,arose from the medial side of the FA, and proceeded medially towards the external genitalia in all the cases(100%). In 2 cases (4%), the DEPA arose from the FA, distal to the PFA origin.

- The PFA arose from the posterolateral aspect of the FA in 64%, from the posterior side of the FA in 24%, from the lateral aspect in 12%.

- The mean length of the PFA origin from the MIP was found to be 4.31cm. High origin of PFA was found in 4%, where it arose 2cm below the MIP.

- The LCFA originated from the PFA in 72%, out of which in 4%, all the branches of the LCFA was arising from the PFA directly. The LCFA arose from the FA in 28%, out of which in 8% of cases, the LCFA arose as a CT with PFA.

- The MCFA arose from the PFA in 64%. It arose from the FA in 36%, out of which in 4%, the MCFA arose as a CT with PFA.

- The descending genicular artery arose from the FA in the lower part of the adductor canal, just above the adductor hiatus in all the cases.

- In the radiological study done, out of 25 femoral angiograms studied, normal branching pattern of the FA was found in 84%.Variations in the branching pattern was observed in 12%. Variations included lateral origin of PFA(4%), CT origin of LCFA and PFA(4%), CT origin of MCFA and PFA(4%). SFA obstruction was seen in 1 case (4%).

- Out of 10 CT angiograms reviewed, normal branching pattern of FA was found in 9 cases, and SFA obstruction was observed in 1 case.

There are variations with respect to the origin of the FA, PFA and their branches. This study will be useful to the surgeons and orthopaedicians during surgeries in the femoral region. It will also be useful to the radiologists for interpretation of images, and to the clinicians before proceeding with interventional procedures.

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S.No	Origin of FA	Relation of FV to FA	Origin of SCIA from FA	Origin ofSEA from FA	Origin of SEPA from FA	Relation of SEPA to GSV	Origin of DEPA	Site of origin of PFA	Distance of origin of PFA-cm	Site of origin of LCFA	Site of origin of MCFA	Origin of DEPA
1	At MIP	M	A	S	S	P	FA	P	3.6	PFA	PFA	FA
2	At MIP	M	A	S	S	P	FA	P	3.6	PFA	PFA	FA
3	At MIP	M	S	S	S	NV	FA	PL	5	FA	PFA	FA
4	At MIP	M	S	S	S	NV	FA	PL	5	FA	PFA	FA
5	At MIP	M	S	S	S	A	FA	L	3.8	FA	PFA	FA
6	At MIP	M	S	S	S	A	FA	L	3.8	FA	PFA	FA
7	Lateral	M	S	S	S	NV	FA	PL	4	PFA	FA	FA
8	Lateral	M	S	S	S	NV	FA	PL	4	PFA	FA	FA
9	At MIP	M	S	S	S	A	FA	P	5.2	FA	PFA	FA
10	At MIP	M	S	S	S	A	FA	P	5.2	FA	PFA	FA
11	At MIP	M	S	CT	CT	P	FA	PL	4.6	PFA	FA	FA
12	At MIP	M	S	CT	CT	p	FA	PL	4.6	PFA	FA	FA
13	At MIP	M	S	S	S	A	FA	PL	5	FA	PFA	FA
14	At MIP	M	S	S	S	A	FA	PL	5	FA	PFA	FA
15	At MIP	M	S	S	D	P	FA	PL	4.4	PFA	FA	FA
16	At MIP	M	S	S	D	P	FA	PL	4.4	PFA	FA	FA
17	At MIP	M	S	S	S	P	FA	PL	4.6	PFA	PFA	FA
18	At MIP	M	S	S	S	P	FA	PL	4.6	PFA	PFA	FA
19	Lateral	M	S	S	S	NV	FA	PL	3.2	PFA	PFA	FA
20	Lateral	M	S	S	S	NV	FA	PL	3.2	PFA	PFA	FA
21	At MIP	M	S	CT	CT	P	FA	L	2	PFA	PFA	FA
22	At MIP	M	S	CT	CT	P	FA	L	2	PFA	PFA	FA
23	At MIP	M	S	S	S	A	FA	PL	4.8	FA	PFA	FA
24	At MIP	M	S	S	S	A	FA	PL	4.8	FA	PFA	FA
25	At MIP	M	S	S	S	P	FA	P	5.2	PFA	PFA	FA
26	At MIP	M	S	S	S	P	FA	P	5.2	PFA	PFA	FA
27	At MIP	M	A	S	S	P	FA	PL	5.4	PFA	FA	FA
28	At MIP	M	A	S	S	P	FA	PL	5.4	PFA	FA	FA
29	At MIP	M	S	S	S	P	FA	P	4.5	PFA	PFA	FA
30	At MIP	M	S	S	S	P	FA	P	4.5	PFA	PFA	FA
31	At MIP	M	S	S	S	A	FA	P	3.5	FA	PFA	FA
32	At MIP	M	S	S	S	A	FA	P	3.5	FA	PFA	FA
33	Lateral	M	S	S	S	P	FA	PL	5	PFA	FA	FA
34	Lateral	M	S	S	S	P	FA	PL	5	PFA	FA	FA
35	At MIP	M	S	S	S	A	FA	PL	3.8	PFA	PFA	FA
36	At MIP	M	S	S	S	A	FA	PL	3.8	PFA	PFA	FA
37	At MIP	M	S	S	S	NV	FA	PL	3	PFA	PFA	FA
38	At MIP	M	S	S	S	NV	FA	PL	3	PFA	PFA	FA
39	At MIP	M	S	S	S	A	FA	P	4.6	PFA	FA	FA
40	At MIP	M	S	S	S	A	FA	P	4.6	PFA	FA	FA
41	At MIP	M	S	S	S	P	FA	PL	5.4	FA	PFA	FA
42	At MIP	M	S	S	S	P	FA	PL	5.4	FA	PFA	FA
43	At MIP	M	S	S	S	A	FA	PL	5	PFA	FA	FA
44	At MIP	M	S	S	S	A	FA	PL	5	PFA	FA	FA
45	At MIP	M	S	CT	CT	P	FA	L	3.4	PFA	PFA	FA
46	At MIP	M	S	CT	CT	P	FA	L	3.4	PFA	PFA	FA
47	At MIP	M	S	S	S	NV	FA	PL	4	PFA	FA	FA
48	At MIP	M	S	S	S	NV	FA	PL	4	PFA	FA	FA
49	At MIP	M	S	S	D	P	FA	PL	4.8	PFA	FA	FA
50	At MIP	M	S	S	D	P	FA	PL	4.8	PFA	FA	FA

FA-Femoral Artery
MIP-Midinguinal point
M-Medial
S-Separate trunk
CT-Common Trunk
A-Anterior
P-Posterior
NV-Not visualised
PL-Posterolateral

MEAN = 4.312

L-Lateral
PFA-Profunda femoris artery